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of Resources in Indiana

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INTRODUCTION

This semi-annual status report covers the period from June 1, 1975 to November 30, 1975 and contains a review of the research and applications, completed or in progress, as funded by the Office of University Affairs, NASA and conducted by Purdue University, Laboratory for Applications of Remote Sensing.

This reporting period marks the beginning of the third year of funding for a proposal entitled "The Application of Remote Sensing Technology to the Solution of Problems in the Management of Resources in Indiana." As indicated in this title, the purpose of this work is to introduce remote sensing into the user community within the state of Indiana. The user community includes those local, regional and state agencies involved in the decision monitoring and/or managing processes of the state's resources.

In order to carry out this work it is not only necessary to initiate projects with these agencies but also it is necessary to meet with and provide information to as many people and groups as well as agencies as possible. During the past six months numerous meetings were held with seventeen different groups.

Among the groups that were contacted and received information about this program were:

Indiana Bureau of Mines
Indiana Highway Commission
Area Planning Commission, Boone County
Indiana Heartland Coordinating Commission
Indiana Geological Survey, Industrial Minerals Section
Holcolm Institute, Butler University
U. S. Forest Service
Yorktown, Indiana Town Board
Yorktown, Indiana Plan Commission
Yorktown, Indiana Board of Zoning
Delaware County - Muncie Metropolitan Department of Planning and Zoning
Ohio River Basin Commission
Save the Valley Organization
Area Plan Commission of Grant County
Tipton County Commissioners and Engineers
Society of American Foresters Annual Convention
Indiana Academy of Science Meetings.

Listed below are the projects that are in progress or completed and reported in this document. The "Highway Route Location" and "Evaluation of Gravel Deposit" reports are presented as scientific papers which have been submitted for publication.

Land Use Inventories

1. Highway Route Location, Ft. Wayne, Indiana

Water Resources

1. Power Plant Siting and Thermal Discharge
2. Inventory of Surface Water in Indiana

Technique Development

1. Data Base
2. Evaluation of Gravel Deposits, Southwestern Indiana

Demonstration Projects

1. Soils Inventory
2. Forestry

LAND USE INVENTORIES

HIGHWAY ROUTE LOCATION UTILIZING REMOTE SENSING TECHNIQUES, FT. WAYNE, INDIANA

S. G. Jordan and T. R. West

INTRODUCTION

The objective of this project was to determine the utility of using MSS data for a highway route selection and, in particular, for a proposed by-pass around the Ft. Wayne, Indiana area. This project was performed in conjunction with the Indiana Highway Commission. Using the beginning and end points supplied by the Commission as control points, a preferred route corridor for a dual-lane, interstate quality, by-pass around the northeast quadrant of Ft. Wayne, Allen County, Indiana was recommended on the basis of remotely sensed data analyzed and machine processed at LARS.

METHODS

Although resolution is limited for satellite data, past experience has shown that in some instances much greater detail than anticipated can be obtained from it. By working in an area where good surface information is available for comparison, it can be ultimately determined whether the technique would be useful in areas where ground control is lacking.

The data analyzed consisted of 1) Skylab IV imagery taken January 25, 1974 and 2) LANDSAT imagery of June 8, 1973. For purposes of ground truth, the following were used: 1) 9" x 9" black and white aerial photography flown April 29, 1975, 2) the agricultural soils map of Allen County[2], 3) the engineering soils map of Allen County[3] and 4) the USGS 7½ minute topographic quadrangle maps for the area surrounding northeastern Ft. Wayne.

In Allen County, there are, as illustrated in Figure 1, four major landforms: 1) the Maumee Lake Plain, 2) the Wabash and Ft. Wayne ridge moraines, 3) a series of ground moraines and 4) the Wabash-Erie and Eel River channels and floodplains. In addition to a few minor physiographic features with limited significance to the study, only two of the four major landforms were included in the area of study. The proposed route, if constructed, must originate in the Maumee Lake plain, cross the Maumee River, cross the beach ridge which marks the contact between the Lake Plain and the St. Joseph River Valley to terminate in the Wabash moraine. The route would be required to cross these landforms regardless of the specific route configuration.

The physical parameters considered at the outset of the study were 1) soil properties and 2) optimum river crossings. Included in the right-of-way are locations where hard glacial till might be encountered in shallow excavations (Figure 2) and others where wet, running sand, which could require dewatering, might be found (Figure 3).[1]

Owing to the rapid growth of the Ft. Wayne area in the northeast direction, it became apparent that a route corridor selected only on the basis of soil conditions and river crossings would be inadequate. Additional factors

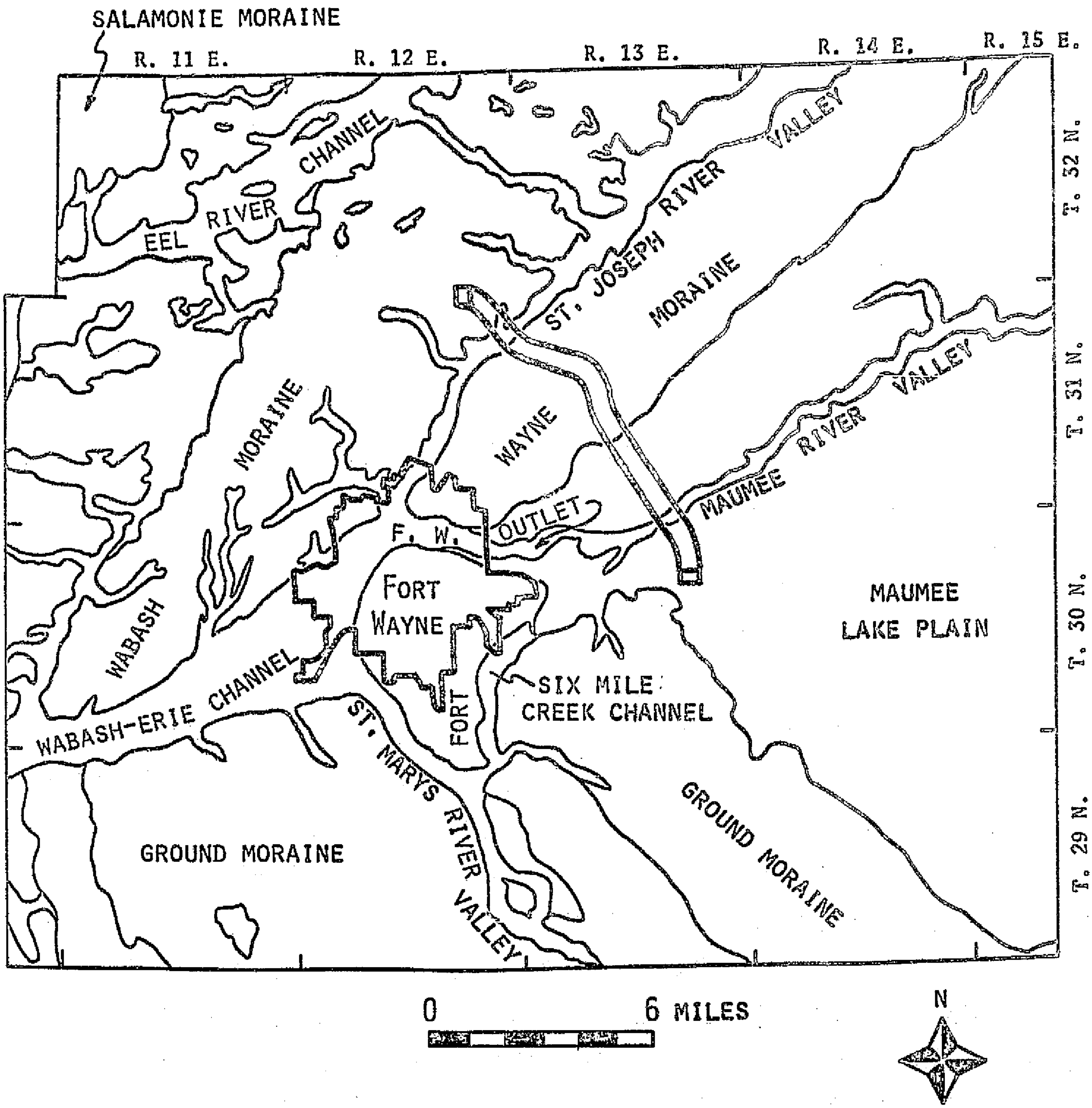

Figure 1. Landform map of Allen County, Indiana showing proposed corridor for dual-lane highway by-pass (base map after Bleuer and Moore (1)).

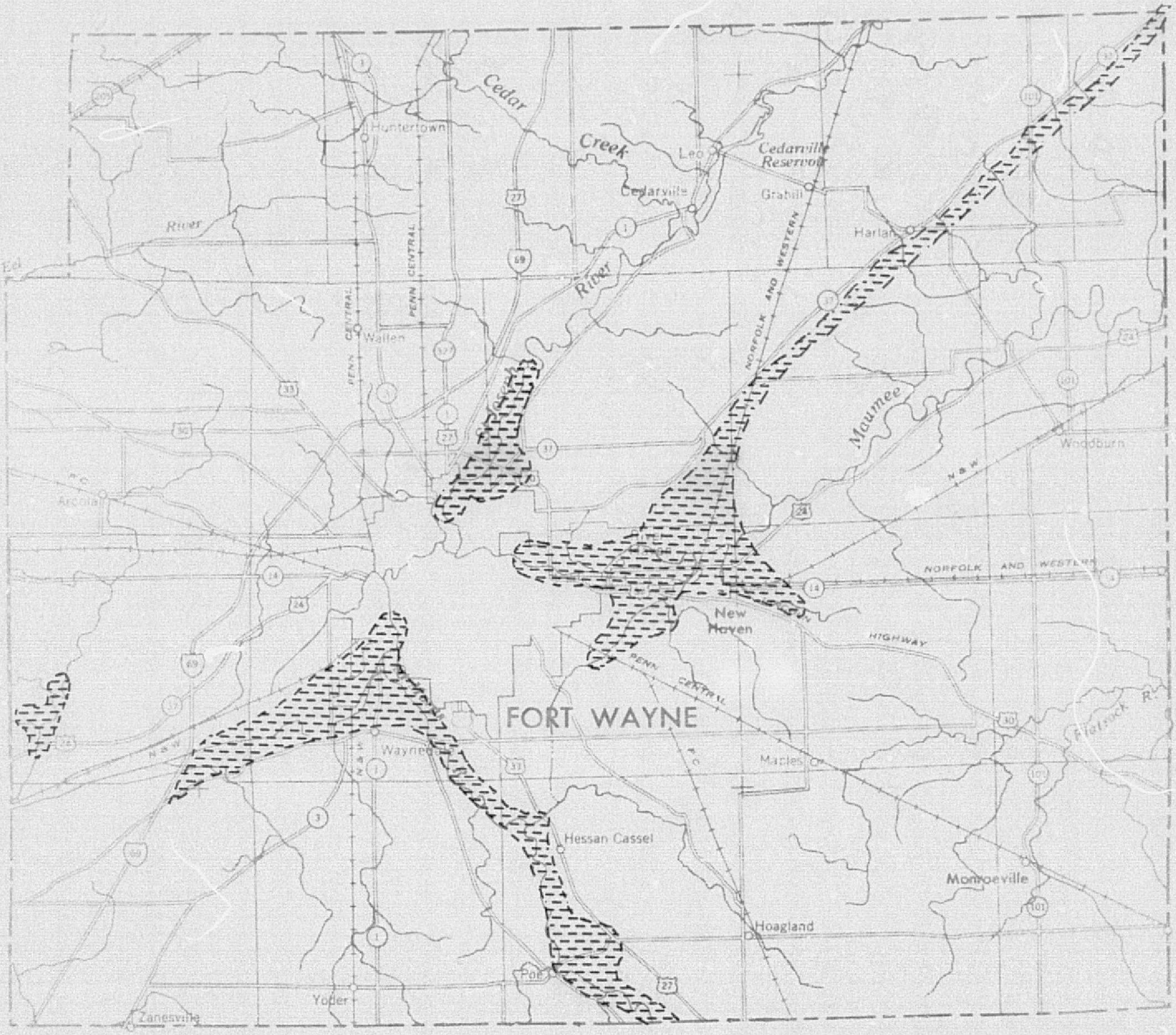

Figure 2. Map showing areas in which shallow excavation may encounter hard till of the Trafalgar Formation or silt of the Atherton Formation. Till may be thinly interlayered with sand and gravel, particularly in Wabash-Erie Channel and Fort Wayne Outlet areas.

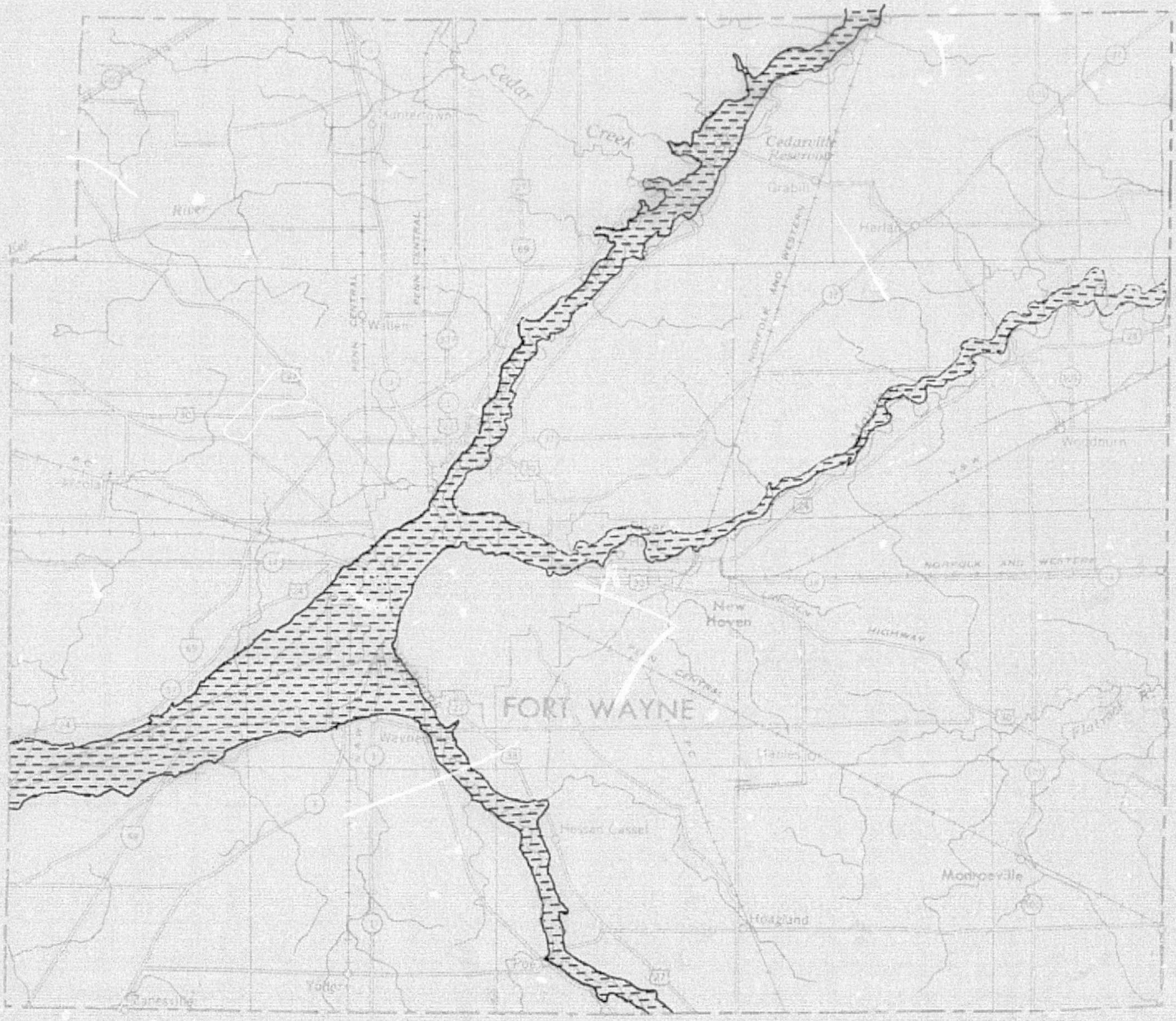

Figure 3. Map showing areas that may be underlain by runny wet sand that may require caissons or dewatering for excavation. Included are some areas of quick sand under high pore-water pressures.

considered were: 1) historic sites (Figure 4), 2) pipelines located in the area (Figure 5), 3) railroad crossings, 4) road crossings, 5) economic factors--including potential mineral sources such as possible quarry and sand and gravel pit development (Figure 6) along with existing and abandoned gravel pits, stone quarries, peat pits and tile kilns (Figure 7), and 6) urban growth. With these considerations added to the basic parameters, the data were analyzed to determine the utility of this approach to highway siting.

A non-supervised classification was performed on the Skylab data. As the area under study consisted of two major landforms, the Maumee Lake plain to the southeast and the Ft. Wayne and Wabash ridge moraines in the northwest, it was subdivided into three portions, one for each of the prevalent zones and a third for the transitional zone around the beach ridge at the Lake plain-ridge moraine contact.

Each of the three zones was divided in half yielding six areas which could be individually clustered using every line and column of data. Unfortunately, the Skylab imagery was taken shortly after a period of heavy rains in the area. There was a large amount of local flooding, and it being winter time, large portions of the area under investigation were coated with ice and snow. Because of this and the coarse resolution of Skylab data, finding points of interest became an involved process. Gray scale printouts of light areas and the spots of snow on the photo imagery were matched and this information transferred to the cluster classifications. It was determined that the locations of dense snow cover coincided with wooded areas on the 9 x 9 black and white photos. It was extremely difficult to match bare soil fields between the Skylab imagery and the aerial photos because of the wet soils and abundant standing water during the Skylab mission. It was never determined for many fields whether they were bare soil, flooded, pasture, stubble or combinations thereof. Ratioing of channels in the visible versus reflective IR was applied in hopes of deciphering this complication, but it also proved unsuccessful.

The net effect of the Skylab data analysis was that bare soil versus short vegetation could not be distinguished. This was caused by the poor surface conditions at the time of flight so that the MSS data were not very useful for cover-type determination. The only category easily discerned was the snow-woods class. If the Skylab data had been obtained under better surface conditions, it is assumed that much better results would have prevailed.

Although the Skylab data were not useful in discerning soil materials, the LANDSAT data proved to be much more suitable for the analysis. As in the case of the Skylab data, the area was divided into three portions. Each of these portions was further divided into two parts thus yielding a total of six areas which could be individually clustered using every line and column of data.

The areas were clustered resulting in gray scale printout cluster maps and fifteen classes of material. Ratioing of the spectral responses in the visible versus the reflective infrared was performed on all the classes to aid in delineating what each class represented. Definable areas on the gray scale printout cluster maps were matched to the aerial photographs. In this manner, the classes delineated by spectral response through the clustering algorithm were defined. Statistics on each subsection were calculated. Classes not spectrally different in a significant way were combined and their statistics merged through the MERGESTATISTICS function of the LARS software system. Subsequently, the classes were passed through the SEPARABILITY program which

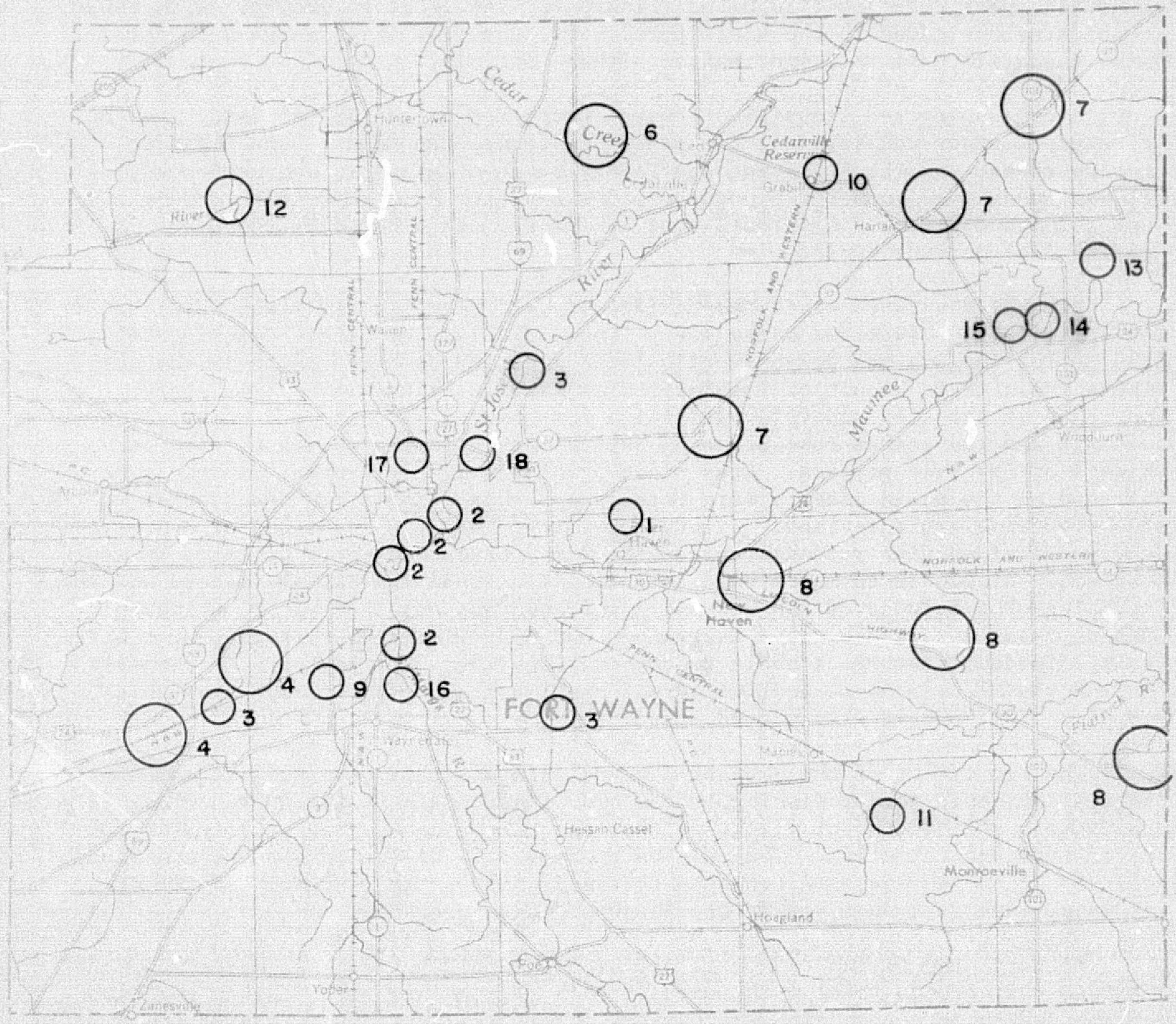

Figure 4. Map showing scenic or historic geologic sites.

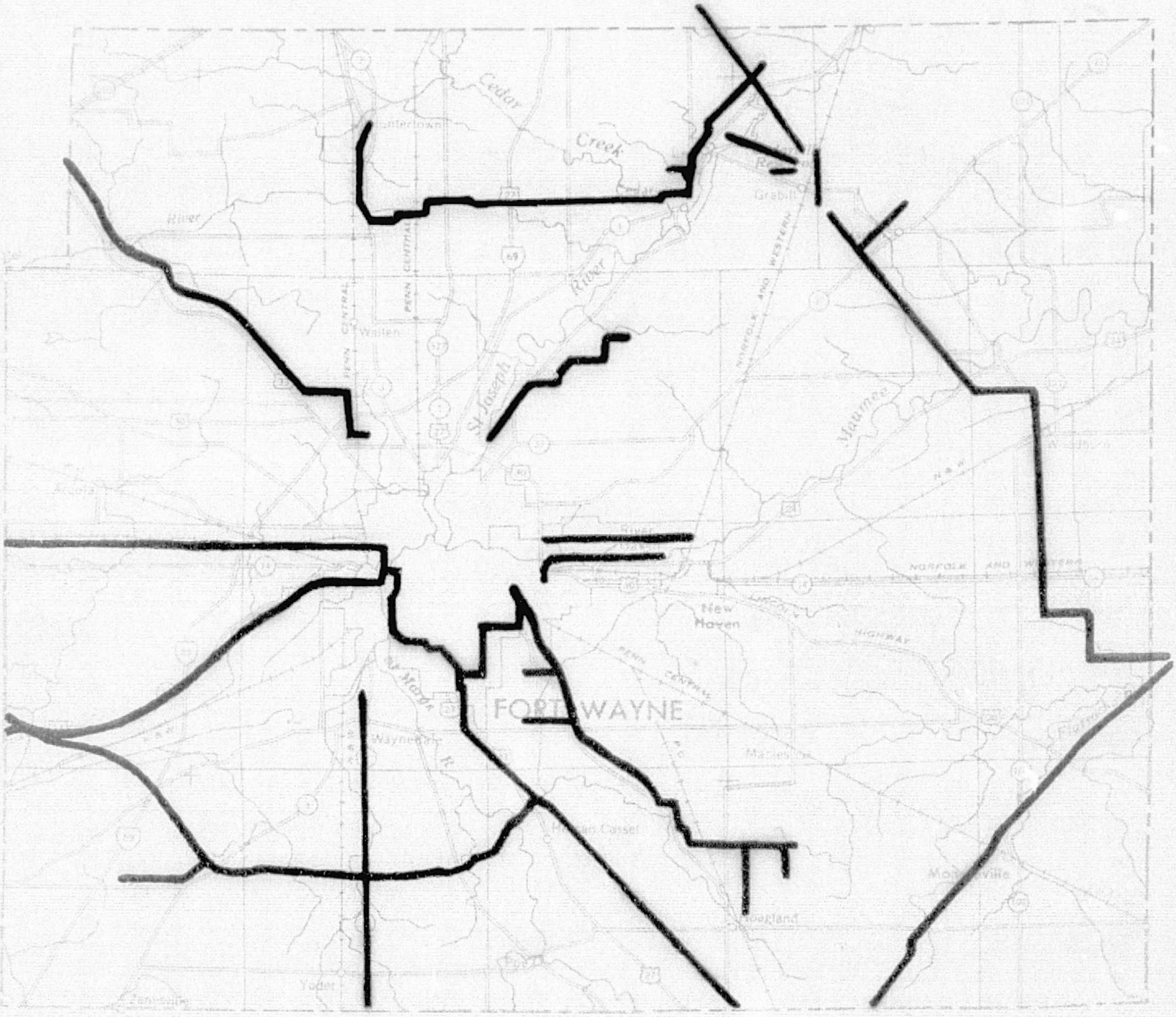

Figure 5. Map showing locations of natural gas pipelines.

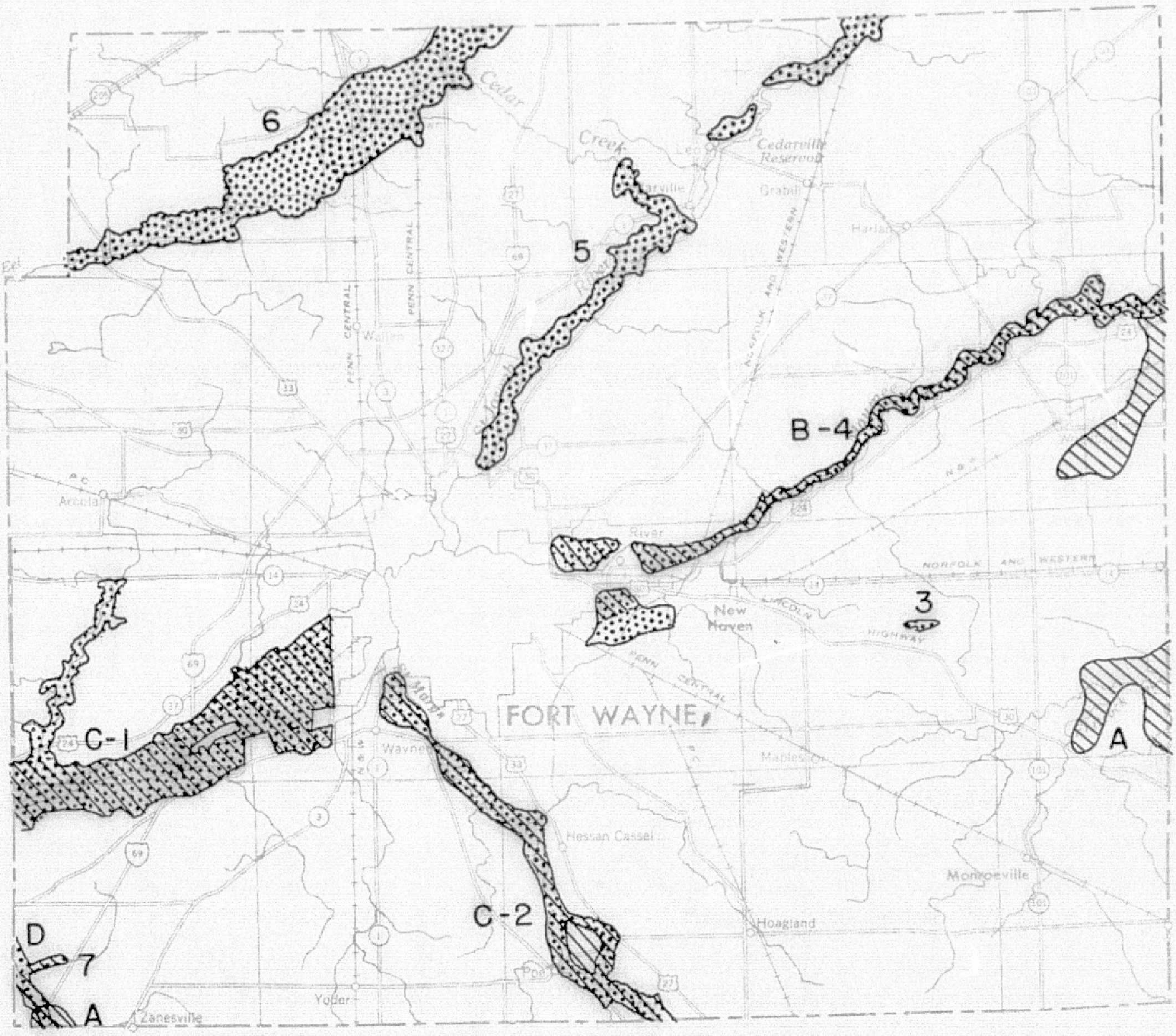

Figure 6. Map showing areas of potential quarry and sand and gravel pit development.

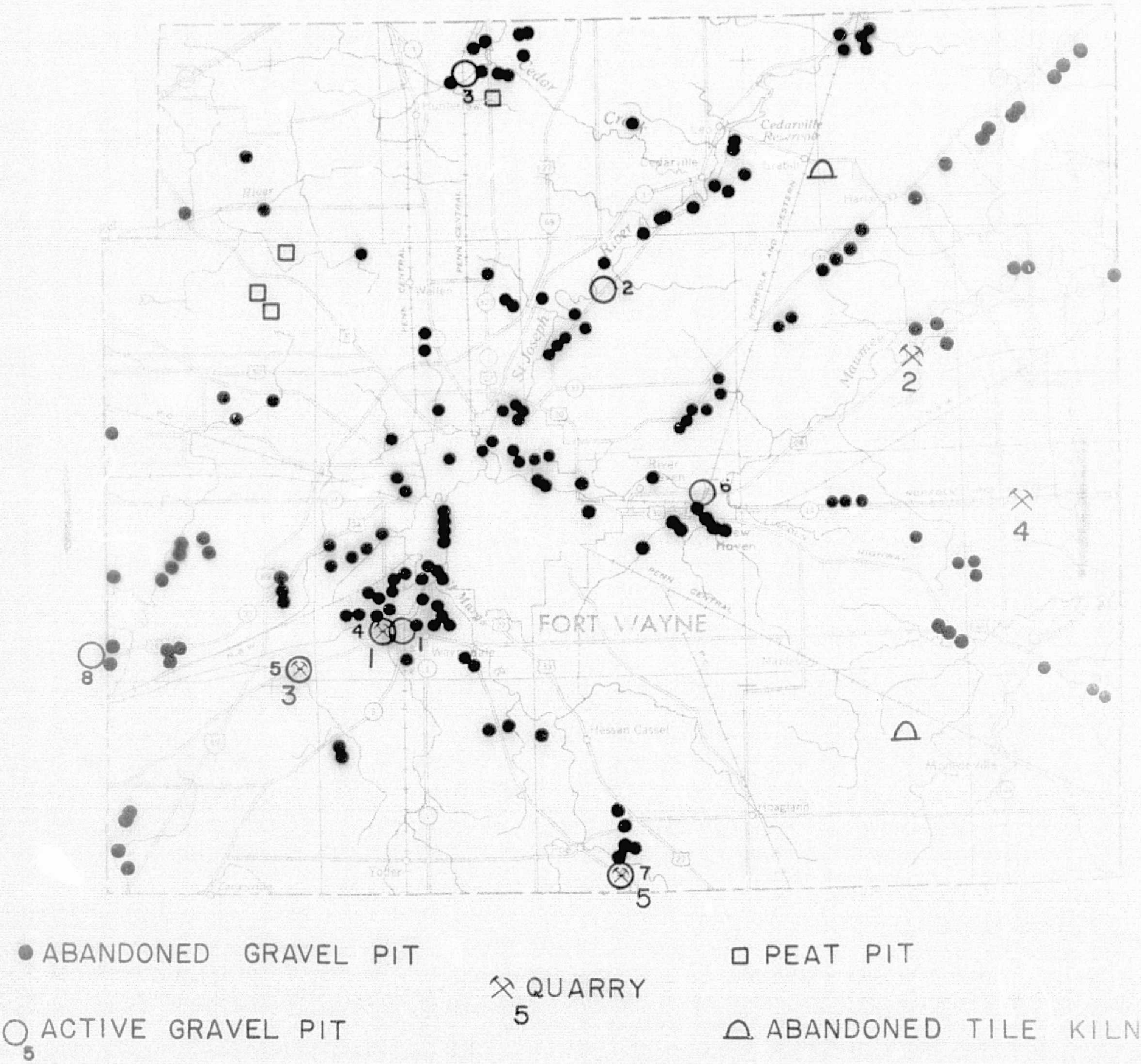

Figure 7. Map showing locations of abandoned and active gravel pits, stone quarries, peat pits, and abandoned tile kilns.

determines how separable the newly merged classes actually are. Similar classes were again combined and their statistics merged. The statistics decks for each half of the three major divisions were merged resulting in a single deck for each of the three major landforms. Next, total area of study was classified three times using each of the statistics decks in turn.

Of the three decks used for analysis only one successfully classified the entire area. That deck, containing statistics from the ground moraine section alone, provided the best results, presumably because training areas for the classes were more distinct for that portion. A gray scale printout of that classification can be seen in Figure 8.

RESULTS

Classification of the LANDSAT imagery contributed positively to the selection of a corridor. Through examination of the imagery and the computer-assisted classification that was generated, the growth pattern of the area and the amount of new suburban development became evident. This allowed for an allocation of adequate room for future growth and development within the route barrier with routing at a prohibitive distance from the city proper. Also, two areas of poorly drained soil which were suspected of containing a moderate amount of organic material were detected. These sites were field checked which verified the conditions suggested by the classification. At the first site, a poorly drained area was found containing $1\frac{1}{2}$ ft. of slightly organic silt with clayey silt below and the water table within 2 ft. of the surface. The second site was much larger and more extensive. It contained 2 ft. of highly organic soil, again underlain by clayey silt with the water table within 4 in. of the surface.

The recommended highway corridor is outlined on Figures 1 and 8. The selection is based on routing the corridor around poorly drained soil areas along with minimizing the distance of intersection with the Lake Maumee beach ridge, while allowing enough area within the confines of the by-pass barrier to permit further expansion of Ft. Wayne but yet missing the existing developments of the area. The Lake Maumee beach ridge feature is preserved because of its aesthetic and cultural value relative to the glacial history of the area. No economically significant geologic materials (quarriable stone, mineral deposits or gravel) underlie the recommended highway route.

CONCLUSIONS

The classification of the LANDSAT imagery allowed detection of poorly drained soils with moderate to significant amounts of organic matter based on their spectral response at spacecraft altitudes. This classification also provided for a direct comparison of these areas which is not possible from a map alone. For the Ft. Wayne study, significant information was added to the published material, and the feasibility of using MSS data in this situation was documented. It was also concluded that this method should prove of greater utility in remote and underdeveloped areas where a "data-gap" exists (relative to surface materials maps primarily), and this procedure could fill the gap of missing information. It is also anticipated that greater detail concerning the engineering properties of the exposed soil could have been determined in this study if lower altitude aircraft scanner data had been available for the site.[4]

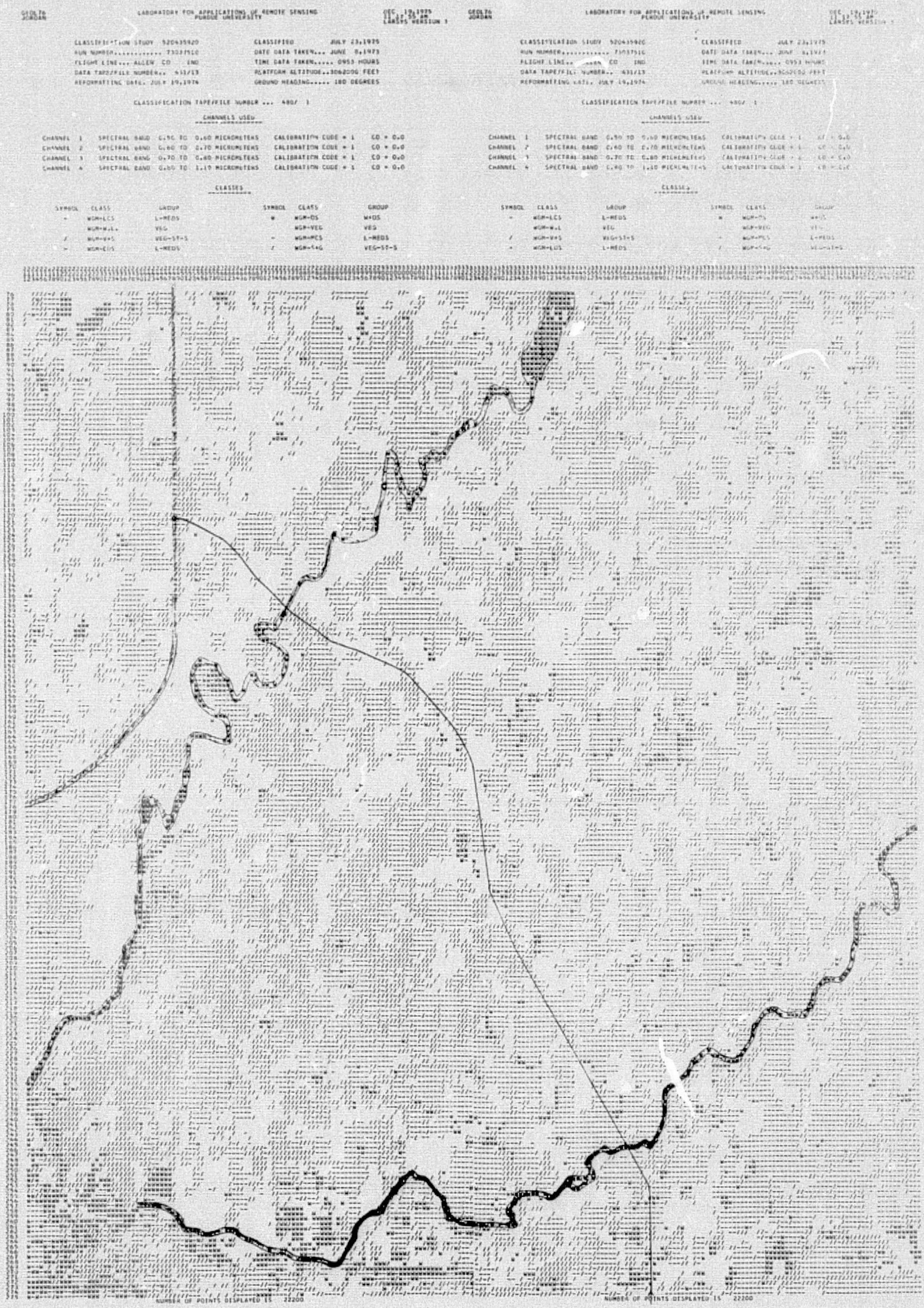

Figure 8. Land use classification, NE Ft. Wayne, Indiana area.

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WATER RESOURCES

POWER PLANT SITING AND THERMAL DISCHARGE

R. E. Bailey and J. Cochran

There are three aspects to this project wherein multispectral scanning techniques are used in the process of siting energy facilities in general and power plants in particular.

Aspect 1. In regard to cooling water discharge from a power plant, the goal is to develop a mathematical model which will allow the calculation of below surface temperature profiles, given the temperature field on the surface of the water is acquired from MSS techniques.

Aspect 2. In regard to decisions particularly in the public domain (concerning the siting of energy facilities and/or power plants), the goal is to use the data handling capabilities of the Regional Inventory Analysis Technique Data Base Program (RIAT) to handle demographic, economic, engineering, environmental and institutional data required for siting decisions. Naturally, this same system can be used for surveillance once the facility is built.

Aspect 3. In regard to helping public policy-makers use and understand the information developed, the goals are to:

a. Make the data acquired available to all levels of the public,
b. Teach the users and potential users how to apply the information available, and the significance of the information itself.

The progress to date on these three aspects is as follows:

Aspect 1. The computer program called THERM3D5 (3-dimensional Thermal Simulation Program Version 5) is being written to calculate below surface temperature profiles given the surface temperature field, the flow rate of heated (or cooled) waters into the stream, and the stream cross section. Since the last 6-month reporting on this project, all of the following final technical improvements and alterations have been made to the program:

1. The inclusion of a solar flux term has been completed. In lieu, however, of the programming of the numbers tables required to make calculation for a given attitude, time of day, and meteorological condition, the program utilizes a layered temperature profile for a mid latitude (30^o-35^o), clear summer day as calculated by R. Hills.[1] This profile is quite characteristic of the atmospheric conditions under which remotely sensed data is taken.
2. The vertical eddy diffusivities are adjusted for thermal stratification by the use of the Richardson number. This approach is in common use in thermal modelling.
3. A velocity profile has been constructed for the jet discharge of heated effluent from a long slot at an arbitraty orientation θ (Theta) with an already established field of flow. This descriptive model is characteristic of the canal and subsurface discharge ports from nuclear- and

fossil-powered electric generating stations now in operation.

4. The internal algorithm for the selection of the initial iterative volumetric temperature profile has been hand-optimized to decrease the absolute number of iterations the model requires for convergence.

5. A cursory error analysis has been concluded which demonstrates that the numerical method employed in the calculation will not add significantly to the measurement or process error.

In addition to the conclusion of technical development on the THERM3D5 model, the verification of the model's predictions is progressing on three levels - two of which are complete and the third in progress.

The first of these verification modes is the isolation, computer subroutine by subroutine, of each of the technical, mathematical, or numerical method sections of the model. Since the model relies heavily for its construction on compartmentalized sub-models, each of these sub-models has been "run through its paces" to locate any bugs or logic flaws. This should instill confidence that few such snags (if any) remain that will be encountered in the operation of the model near its normal range.

The second level of verification consisted of the comparison of the functional dependencies (the "shapes," if you will) of the produced temperature field with recently published data[2] from an operating power plant. Figures 1 and 2 are graphs of the isotherms from the Rush Island Power Plant operated by the Union Electric Company on the Ohio River. Figures 3 and 4 are graphs of the predicted isotherms from a similar run as produced by THERM3D5. Although the geometry of the river bottom is somewhat different, we feel that the correspondence of the shapes of the isotherms is both striking and encouraging.

The third, and final, stage of verification (now in progress) is the point by point comparison of a predicted 3-dimensional profile from THERM3D5 and field-collected temperature data from that same site. The collection of the field data was performed downstream of the Gallagher Power Plant on the Ohio River during the days of late July and early August, 1974, by a previous LARS researcher (C. Kardos). Further, during that same period of time, temperature data was collected by an airborne multispectral analyzer at 8,000 feet altitude. The resulting 35 foot by 40 foot data blocks have sufficient resolution to offer a rigorous test of the capacities of the model THERM3D5. As aforementioned, this comparison is in progress. Preliminary results are very encouraging.

The final step in the preparation of this tool which utilizes remotely sensed data is the documentation step. All the pertinent details of the theory, numerical implementation and experimental verification of this model will be contained in a thesis to be submitted by late February to the Department of Nuclear Engineering at Purdue University, a concurrent Information Note within the LARS structure, and a subsequent technical report to be submitted to NASA. Also, three briefer public airings are planned. The first will address the general points of the techniques for handling this data and comments on its applicability to power plant licensing. The second will be dealing specifically with the application of remotely sensed temperature data to the heat transfer model chronicled herein. The third will consist of the presentation of this research at a conference or symposium dealing with associated topics on a

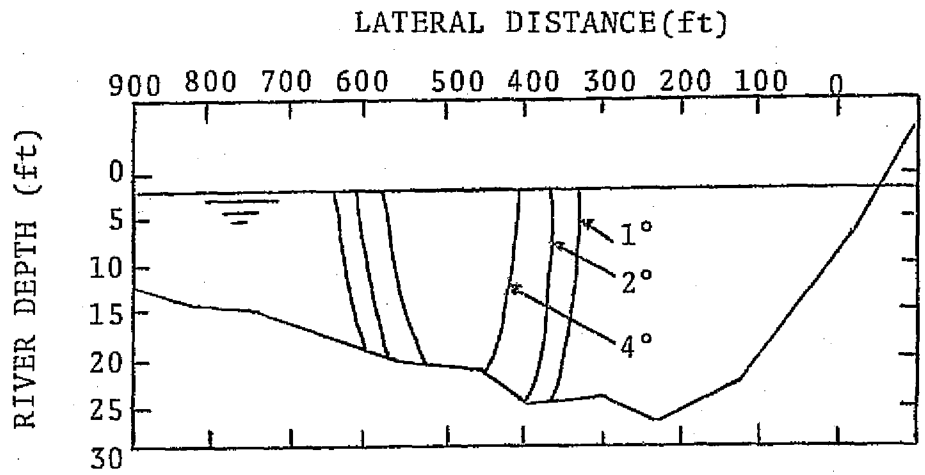


FIGURE 1. CROSS-SECTIONAL VIEW OF SUBSURFACE ISOTHERMS AT 600 FEET DOWNSTREAM FROM SINGLE-POINT SUBMERGED DISCHARGE FOR RUSH ISLAND PLANT, PUBLISHED DATA (2).

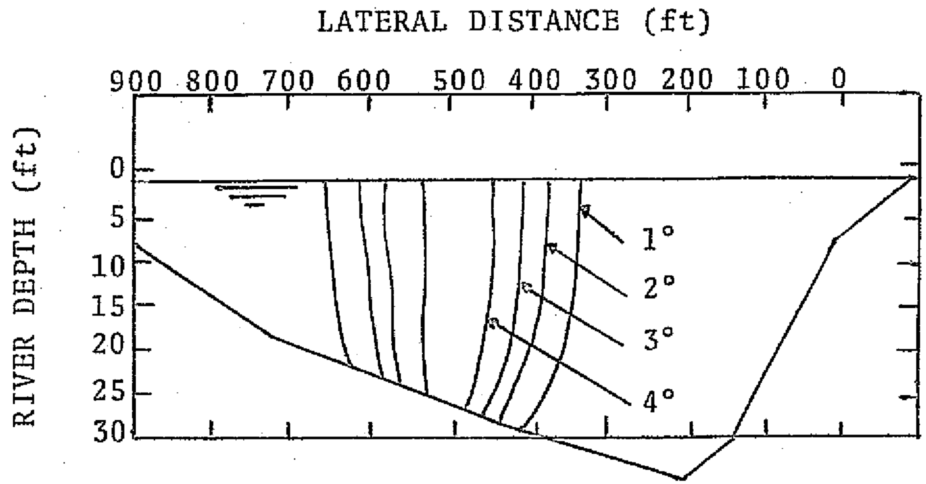


FIGURE 2. CROSS-SECTIONAL VIEW OF SUBSURFACE ISOTHERMS AT 1000 FEET DOWNSTREAM FROM SINGLE-POINT SUBMERGED DISCHARGE FOR RUSH ISLAND PLANT, PUBLISHED DATA (2).

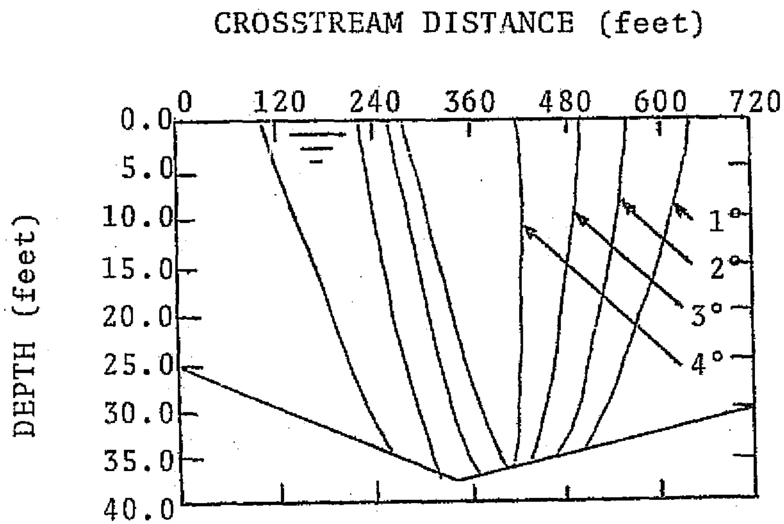


FIGURE 3. CROSS-SECTIONAL VIEW OF ISOTHERMS FROM THRM3D4 SAMPLE RUN, 595 FEET DOWNSTREAM.

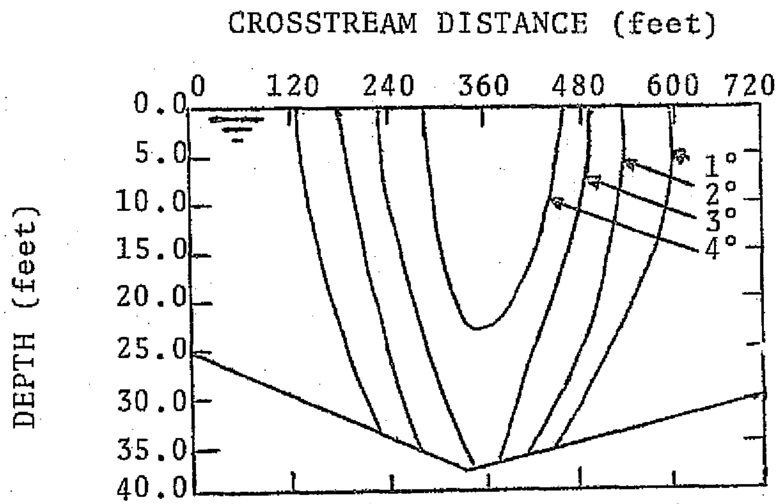


FIGURE 4. CROSS-SECTIONAL VIEW OF ISOTHERMS FROM THRM3D4 SAMPLE RUN, 1015 FEET DOWNSTREAM.

regional or, preferably, a national level. The preparation and submission of these papers to the appropriate screening committees or technical publications will be concluded by May, 1976 with public release, hopefully, shortly thereafter.

Aspect 2. The process being proposed for energy facility siting decisions is built around the Midwest Energy Facilities Impact Study (MEFIS). A statement defining MEFIS is located in Appendix A. Discussions are now in progress with the Office of Research and Development of EPA (Dr. Stephen Gage) to fund such a study. The impetus for EPA to begin such a study came from a recent directive from the Senate Appropriations Committee. A news release from Senator Bayh's office, which was subsequently published in the Louisville Courier Journal, attests to this and the Courier article is attached. LARS, past and on-going, activities in power plant siting, coupled with a citizens group "Save the Valley, Inc." and Indiana University's School of Public and Environmental Affairs played a part in the decision by the Senate Appropriations Committee.

The proposed siting decision process itself is shown schematically in Figure 5. Basically, it is a process wherein a common data base is used for developing alternate energy facility siting decisions both from the private and public sector. These alternate technical solutions to meet an energy need are then compared against institutional frameworks and capabilities. This matching is looked at from the standpoint of the political, legal, fiscal and administrative environment. At this point, the need or non-need for technical or institutional innovations becomes apparent, a strategy to achieve goals and objectives is developed and the decision is made.

This naturally leads to Aspect 3 since we are only teachers and advisors to all groups concerned. They must themselves make the ultimate decision.

Our basic assumption is that given a common data and information base, reasonable decisions will be made on a more timely basis.

Aspect 3. In the fall of 1975, Dr. Bailey from LARS/Purdue, and Drs. Howe and Randolph from the School of Public and Environmental Affairs of Indiana University spent two days in Madison, Indiana with Save the Valley, Inc. The two-day visit culminated in a public meeting held in Madison, Indiana. News releases of that visit and the subsequent meeting are attached.

Besides Save the Valley, Inc., the Ohio River Basin Commission is becoming interested in this whole activity and a meaningful dialogue is beginning to develop.

Furthermore, Dr. Bailey was awarded a continuing education grant from the Indiana Commission on Higher Education to develop a continuing education program for policy makers regarding the siting of Electrical Generation and Transmission Facilities. The grant termination on July 1, 1976 is unrenewable. The funding came from Title I of the Higher Education Act of 1965. Hopefully, funds to continue this educational aspect will be forthcoming through the above-mentioned contract with EPA (if it becomes a reality) or from some other source.

In summary, it appears that the seeds planted by the PY funding of the LARS power plant siting activity are struggling to bear fruit and to propagate, with special emphasis on getting the information (acquired and handled through NASA-developed techniques) into the hands of public policy makers.

Louisville Courier-Journal
Wednesday, July 23, 1975

EPA told to study impact of power plants on river

By WARD SINCLAIR
Courier-Journal Staff Writer

WASHINGTON — The Senate Appropriations Committee yesterday ordered a "comprehensive" federal study of the potential environmental impact of the construction of large electric power plants on the Ohio River.

The action was taken at the urging of Sen. Birch Bayh, D-Ind., who said that reports of a future concentration of power plants along the lower Ohio have stirred citizen concern and raised serious social issues.

Bayh's proposal to the committee stemmed from a meeting last year with representatives of Save the Valley, a citizen group based at Madison, Ind., worried about power companies' building plans in the area.

The group has protested that as many as four new generating plants, in addition to two existing stations, eventually may be erected along a 60-mile stretch of the river between Louisville and Vevay, Ind.

The committee directed the Environmental Protection Agency (EPA) to assess environmental, social and economic impact of the concentration of plants on the lower Ohio basin.

Under the committee directive, EPA's study would cover the stretch of the river from Western Ohio to Western Illinois.

The directive to EPA calls for a full-scale study of the impacts of air, water and solid pollutants on the residents and natural environment of the region.

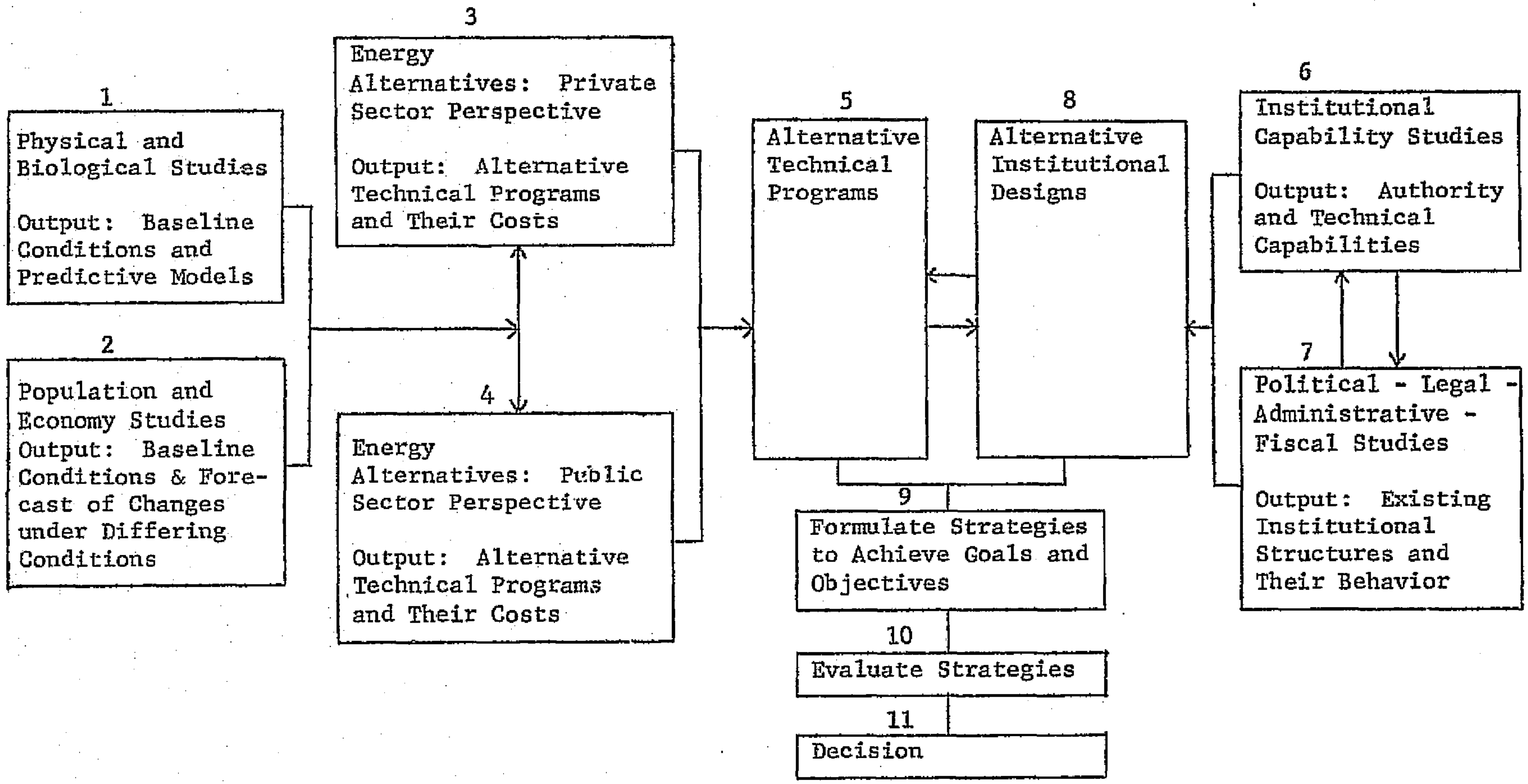
The committee also said the study should "take into account the availability of coal and other energy sources in this region" while assessing the social and economic consequences of further construction of power plants.

Bayh said he contacted the presidents of Indiana and Purdue universities and was assured by both that faculty members would be interested in assisting EPA in the study.

A five-man study team from the two schools is planning to submit a study proposal to EPA later in the summer, Bayh said. The team will seek assistance from other schools in the region as soon as the scope of the investigation is agreed upon, he said.

FIGURE 5

ANALYTIC FRAMEWORK FOR MIDWEST ENERGY FACILITIES IMPACT STUDY



The Madison Courier
Saturday, October 11, 1975

Study team

Four IU-PU professors arrive Monday

By STEVE WHITE

The Indiana University-Purdue University team of four professors working on the Land Use Study for the Lower Ohio River Basin will arrive in Madison Monday.

They will be here to observe, to become acquainted with the communities involved and to meet with the people of the area.

During this visit the professors will present an important informational program on the study at 7:30 p.m. Tuesday in the Madison-Jefferson County Public Library auditorium.

The meeting is sponsored by Save The Valley and is open to the public.

Environmental studies are presently being conducted by the federal government in the northern great plains, the southwest, and elsewhere in the nation where concentrations of power plants are being planned.

However, there is no similar study for this portion of the Ohio River Valley in general and Madison in particular.

Lacking any other means of identifying and avoiding such effects of concentration of plants, this IU-Purdue study team will attempt to create a body of information that will be available, usable and reliable for those making decisions on power plant sitings.

The team will consist of Professor Robert Bailey, nuclear engineering department at Purdue University; Professor Nicholas White, Indiana University Law School; Associate Professor Richard Howe, school of public and environmental affairs at Indiana University; and J. C. Randolph, assistant professor in the school of public and environmental affairs at IU.

They have been participating in energy conferences and have applied for a grant to complete the study. When completed, the study will be a pattern for the rest of the country and a model to educate school children.

At 7:30 p.m. the four professors will meet for dinner at Clifty Inn with Save The Valley officers and board members for a preliminary discussion.

Tuesday morning they will go by car from Milton to Ghent, stopping at farm houses along the way to talk to the residents and look over the valley.

Tuesday afternoon they will go by boat from Madison to Bethlehem. On both trips they will be escorted by Save The Valley officers and board members.

The two-day visit will culminate in the meeting Tuesday evening at the library to discuss what they have seen and what they hope to do.

The study team's published "Overview of the Impact Study" states reasons for such a study. Among these are the plans for a concentration of energy producing facilities along the Ohio River from Cincinnati downstream to the Mississippi River, with five plants being planned for the 30-mile stretch near Madison, or a total of seven.

Reasons given in the overview as to why so many plants are planned in one area are availability of coal and water, sparce population, available river and rail transportation, and technological know-how to transmit power for long distances.

Additional reasons noted for siting plants in the immediate

See back page, column 1

Continued from page 1

area of Madison are that stricter clean air standards and water effluent limitations make siting in urban areas difficult and the less effective control and regulation in such areas, because the local and affected citizens are not accustomed nor prepared to cope with problems of this magnitude.

The interstate location of the river makes the problem of control more difficult. Pollution created on one side of the river can affect the other side more disasterously, according to Save The Valley and the study team.

The overview prepared by the study team also details the work approach to be used. A grid is to be established to which will be added information on population, land formation, climatic conditions, and economic data. More detailed study will be done on the water quality and quantity, air quality, geology, soil, animals, and vegetation, as well as other related areas such as agricultural productivity and sociology-human interface.

A study of this type can only go so far, according to Save The Valley. It can identify problems and offer alternatives. What actually happens to the Ohio River Valley and Madison will depend on the informed opinions expressed by the people who live here, the local organization pointed out.

The Madison Courier
Wednesday, October 15, 1975

Impact!

Professors view 'valley' area

By STEVE WHITE

Areas proposed as the sites for power plants in the Ohio River Valley were visited yesterday by a team of Indiana University and Purdue University professors.

Professor Robert Bailey, nuclear engineering department at Purdue, Associate Professor Richard Howe, school of public and environmental affairs at IU, and J. C. Randolph, assistant professor in the school of public and environmental affairs at IU, along with Professor Nicholas White (who was unable to come due to a teaching conflict), IU law school, compose a study team that plan to do a Midwest Facility Impact Study.

They started on the project a year ago when a senator contacted the university presidents and asked if there was anything that could be done to deal with all of the power plant sitings planned in the midwest area (east of Cincinnati, southwest Ohio, northern and western Kentucky, and a large portion of southern Indiana and Illinois).

The professors have applied to the Environmental Protection Agency for a grant to cover the study and are leaving Thursday for a conference on the grant.

The three professors traveled by car to Ghent, Ky., yesterday morning, stopping to talk with different people that would be affected by additional plant sitings. Mrs. Virginia Coleman conducted the morning tour.

In the afternoon, Robert Slover and Tom Roller took the men by boat to Bethlehem to view possible plant sitings.

Last night they spoke to Save The Valley members, each explaining partially what the study will entail and asked what the people's priorities are.

They stressed that the study will not be pro or con on the plant sitings, but instead will give information, details and figures on a variety of aspects concerning environmental impact of a concentration of power plants. This information then can be used by the public.

Howe said the study is in a "pre-proposal state" and they are working on developing the study design.

Physical, economical and social impacts will be brought out in the report through Howe, along with atmospheric, aquatic and terrestrial conditions.

Bailey said that "my concern is not nuclear power, but that the study will give me a chance to bring what I know of the nuclear technology out to the people. It will be a chance to get rid of the myths and use facts and figures."

He listed 12 points that he will include in the study as examples of issues people need good information on to judge the plant sitings.

The 12 points were: value of the facility from the time started to time completed; effect of facility on cost of electricity to the customer; effect of facility on tax revenue; how to warp the tax revenue to benefit the community; size, mix and skills of labor force to build facility; type and number of people required to operate facility; movement of resources to facility; visual appearance of facility; nature of environmental impact during construction and when completed; movement of heat; describe how radioactivity moves; and come up with a group of alternate locations for the plants.

Howe said the underlying purpose of the study is "to make the game a bit fairer."

Randolph, a former employe of the Atomic Energy Commission who wrote environmental impact studies, said many methods will be used to establish areas that have potential as major energy facility sites.

They said the negotiations are going well for the study and they are very optimistic and by spring should be ready to do some work.

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2. Union Electric Company, Bechtel Corporation, Westinghouse Environmental Systems Smith-Singer Meteorologists, and Harlan Bartholomew and Associates. Draft Environmental Statement - Rush Island Power Plant. Corps of Engineers, Department of the Army, U.S. Army Engineering District, St. Louis, Missouri, pp. 57-58 (1972)

APPENDIX A

WHAT IS MEFIS?

The Midwest Energy Facilities Impact Study (MEFIS) is a joint research effort proposed by the School of Public and Environmental Affairs, Indiana University and the Interdisciplinary Engineering Studies Division and the Laboratory for Applications of Remote Sensing, Purdue University. This study will provide information and analytical capabilities that will enable public sector decision making processes to evaluate alternative energy facilities with sophisticated tools used by the private sector. The primary focus of the study will be toward assisting people, acting through their institutions, to deal effectively with the problems and opportunities of energy facilities developments.

For the purpose of this proposed research program the terms midwest, energy facilities, and impacts are defined as follows:

Midwest means southwestern Ohio, southern Indiana, southern Illinois and western Kentucky;

Energy facilities means any facility that extracts, transports, processes, generates, transmits or disposes of energy or by-products;

Impacts means environmental, economic, social, political, and institutional impacts of energy facilities planning and management design and construction, operation and maintenance, and regulation.

The study will be a cooperative effort among entities having an interest/stake in the outcome and/or capabilities to perform specific aspects of the study. Primary guidance and coordination of the proposed study will be provided by Indiana University and Purdue University.

Funding for MEFIS is being sought from the U.S. Environmental Protection Agency. The EPA has been receptive to this idea of MEFIS and helpful in developing the study design.

Citizen action provided the initiative for this study--Save the Valley along with Save Marblehill, Knob and Valley Audubon Society and others articulated the key issues regarding the implications of building or not building large energy facilities.

Senator Birch Bayh has provided extensive help in obtaining information and access to key people. He has been particularly helpful in linking Purdue University and Indiana University so that their respective strengths can compliment each other in seeking solutions to the very real energy problems ahead.

INVENTORY OF SURFACE WATER IN INDIANA

L. Bartolucci

BACKGROUND

Although Indiana is not known as a lake state, the three northernmost rows of counties contain over 500 natural lakes greater than five acres in size, and some of them are larger than 500 acres. In addition, there are a large number of man-made water bodies (reservoirs) and also thousands of small farm ponds. Winters (1973) believes that there are over 15,000 of these small ponds throughout the state of Indiana.

In order to conduct a water quality evaluation in the state of Indiana, it is essential to determine, first of all, the location and extent of all water bodies, that is, to carry out a comprehensive and accurate inventory of the available surface water throughout the state. Also, because both the quantity and quality of the surface water depends on dynamic variables, repetitive (timely) data collection and analysis procedures are desirable.

The conventional method of determining and monitoring the areal extent of surface water is based on water-level readings obtained by in situ gauging instrumentation located at selected sites. In general, however, the small number of gauging stations limits the accuracy of estimating the areal extent of the available surface water. The state of Indiana, for example, which has more than a thousand natural and artificial lakes of five or more acres in size, has only one hundred or so gauges in operation at the present time.

To date, several attempts have been made to utilize LANDSAT imagery to map the location and areal extent of water bodies. McKim and co-investigators (1973) have used LANDSAT imagery in the National Program for the Inspection of Dams. They have reported that water bodies larger than 5 acres in surface area could be identified in the imagery. Reeves (1973) conducted a census of thousands of small playa lakes in the Texas High Plains using photointerpretation of LANDSAT-1 multispectral images.

Although conventional photointerpretation of satellite imagery has yielded valuable results in the area of remote sensing of water resources, it has also some inherent limitations such as the subjectivity of the human factor involved in the interpretation, and above all, the limitations of the photographic products.

Previous results of applying computer-aided analysis techniques to digital multispectral scanner data have revealed the tremendous potential that these techniques offer for rapid, objective, and comprehensive mapping of natural resources. It has been also found that computer-aided analysis techniques can provide an improved estimation of the surface area of water bodies through the use of each individual data point in a digital format before degradations are introduced by the reproduction of the data into photographic films. The improvement in acreage estimations is also due to an increase in reliability to discriminate and identify water using multispectral pattern recognition algorithms. However, the acreage determinations of surface water using computer-aided techniques have shown a consistent error (underestimation) which is a function of the

actual size of the water bodies (large error for small lakes and vice versa). This underestimation results from the coarse spatial resolution of the LANDSAT MSS system ($\approx$1.12 acres per resolution element).

OBJECTIVES OF THE INVESTIGATION

The purpose of this study is to develop and test correction criteria that would take into account those resolution elements that cover only partially a certain area of water and a portion of another cover type, such as forest, which are often found around the edge of reservoirs and lakes.

ANALYSIS PROCEDURES

A set of LANDSAT-1 MSS data (Scene ID: 1285-15595) collected on May 4, 1973 over northern Indiana was reformatted to render it compatible with the LARS system. Figure 1 shows the entire LANDSAT-1 frame used in this investigation. One half of the LANDSAT frame was classified into four different spectral groups as shown in Table 1.

Table 1. Spectral Classes for Acreage Estimation of Surface Water

1. Water
2. Forest
3. Crops
4. Soils

The surface area of the water bodies was computed by multiplying the number of resolution elements classified as water times a conversion factor of 1.12 acres per resolution element. The resulting acreages estimated from the LANDSAT-1 data were compared to the acreages published by the U.S.G.S. for those reservoirs where gauging stations continuously monitor the water level. This comparison showed that there was a consistent underestimation of the size of the lakes.

It seems reasonable that this underestimation should be expected because of the errors introduced by the coarse spatial resolution of the LANDSAT MSS system. It is obvious that if a resolution element partially covers an area of water and some other cover type (at the edge of the water body), it will not be classified as water. Therefore, a fifth spectral class was defined as a mixture of the spectral response of water and that of forest. Table 2 shows the spectral responses for the five spectral classes used in a second classification.

Table 2. Spectral Response for Five Ground Cover Types

	LANDSAT Bands			
Spectral Class	4	5	6	7
Water	25.1	18.3	12.2	3.3
Water-edge	27.3	20.8	25.6	12.3
Forest	29.4	23.3	42.3	24.4
Crops	31.0	24.5	53.8	32.6
Soils	41.9	45.6	49.5	21.9

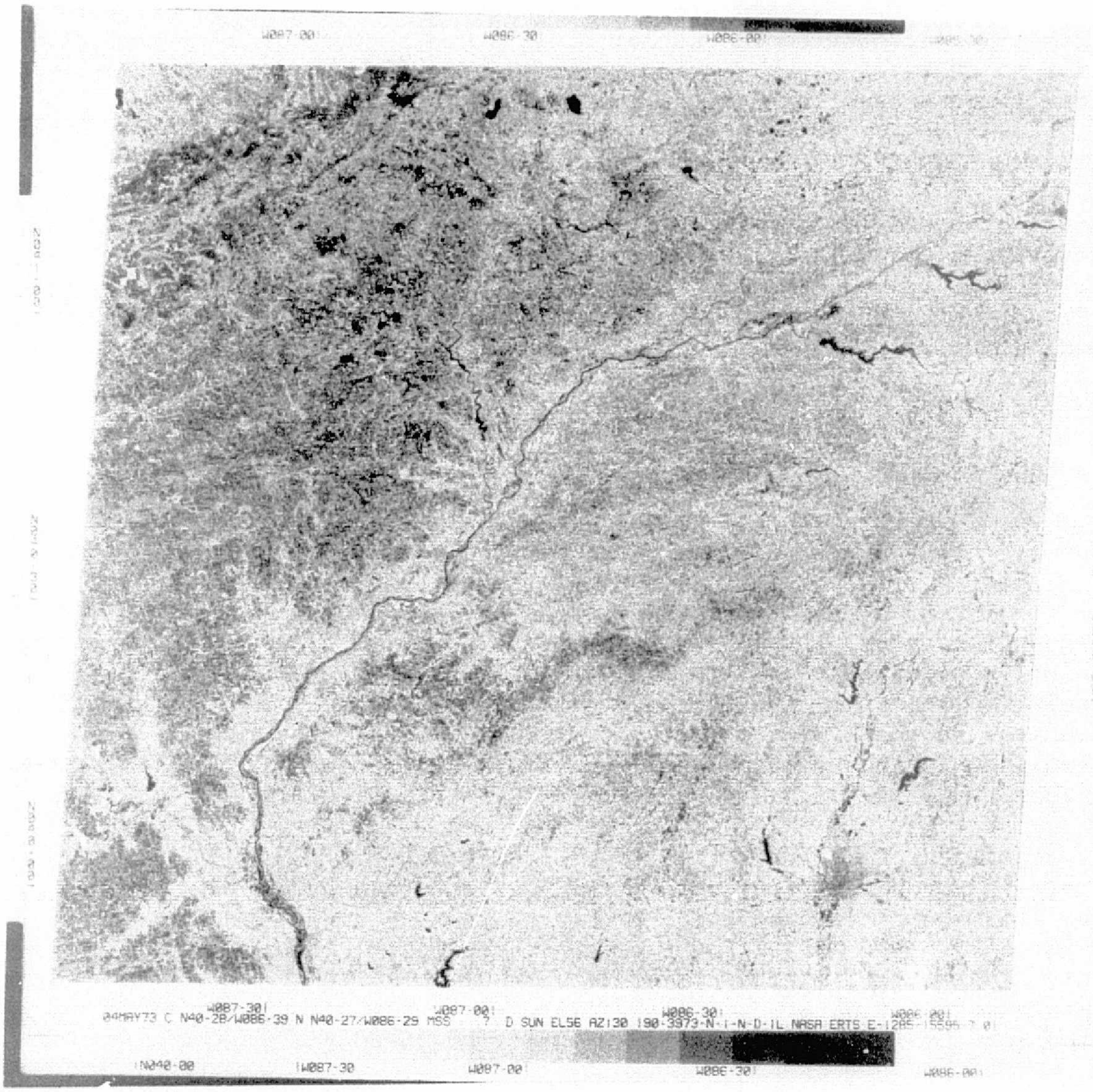


Figure 1. LANDSAT-1 imagery used for the inventory of surface water in northern Indiana.

Note in Table 2 that the spectral response for the water-edge class (shown by an arrow) appears to be somewhat between the spectral responses of water and forest. Analysis of the low altitude photography obtained at the same time of the satellite overpass showed that the water bodies under consideration were surrounded by dense forest. Figure 2A shows the resulting classification (of five spectral classes) of an area including Lake Freeman near Lafayette, Indiana. Note that only the water class (M) and the water-edge spectral class (·) have been printed. The crops forest and soil classes were displayed as blanks. In Figure 2B only the water-edge class was displayed in the resulting computer-generated map.

In order to determine the proportion of water and of forest that would yield a spectral response equal to that of the water-edge class, a linear combination of spectral signatures was utilized. The physical and statistical considerations for the justification of the linear combination of spectral signatures will be discussed in detail in the final report. For the time being, let us determine the proportion of a resolution element composed of water and of forest.

Let "x" and "y" be the proportion (percentage) of water and forest respectively that would yield, upon mixing, the spectral response of the water-edge class. The known spectral responses for the water, forest, and water-edge classes (Table 2) are represented by the coefficients a_n, b_n, and c_n respectively; where "n" is the channel number* (n=1,2,3, and 4). Because there are only two unknowns (x and y), only two spectral bands are necessary to solve for x and y in a system of two linear equations.

$$c_1 = a_1x + b_1y \qquad (1)$$

$$c_4 = a_4x + b_4y \qquad (2)$$

The coefficients in equations (1) and (2) can be obtained from Table 2, and they are equal to:

$$a_1 = 25.1 \qquad a_4 = 3.3$$

$$b_1 = 29.4 \qquad b_4 = 24.4$$

$$c_1 = 27.3 \qquad c_4 = 12.3$$

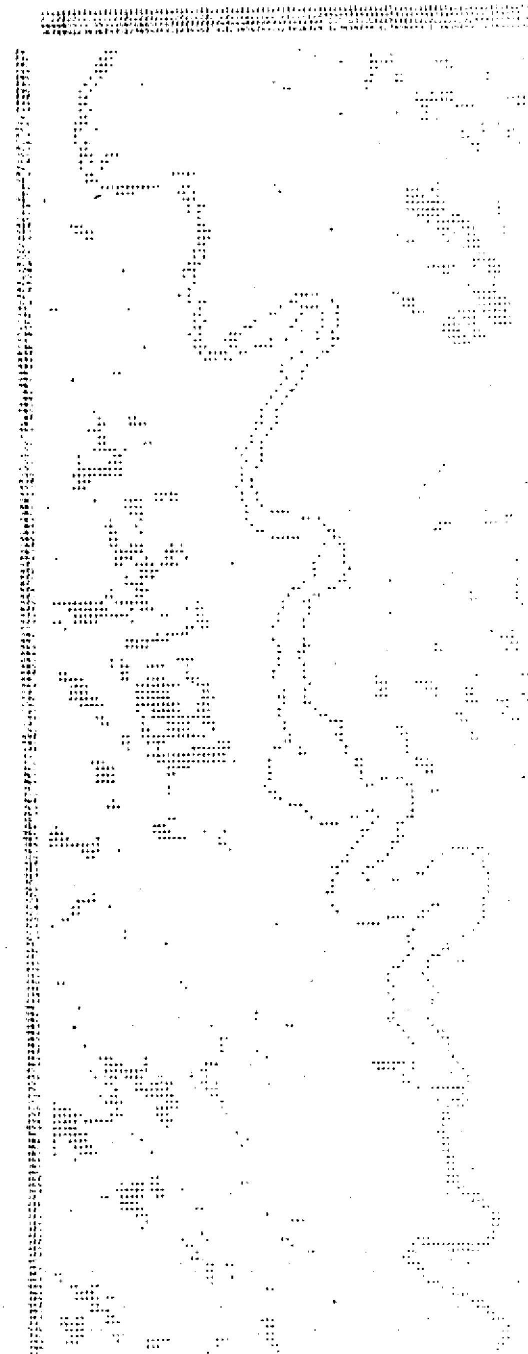
Substituting these values in equations (1) and (2) one obtains the following two linear equations with two unknowns x and y.

$$27.3 = 25.1x + 29.4y \qquad (3)$$

$$12.3 = 3.3x + 24.4y \qquad (4)$$

*At LARS, the LANDSAT bands 4,5,6, and 7 correspond to channels 1,2,3, and 4, respectively.

(A)



(B)

Figures 2. Multispectral classification of the Lake Freeman area near Lafayette, Indiana. (A) shows the water and water-edge spectral classes. (B) shows the water-edge spectral class only.

Solving for x and y one obtains the proportions or percentages of water and forest that would produce the spectral signature of the water-edge class:

$$x = 59\% \tag{5}$$

$$y = 41\% \tag{6}$$

Therefore, if all the water-edge pixels (·) surrounding the water body are counted and 59% of their area is added to the previously estimated water area, the result should be a corrected estimation of the size of the water bodies that would account for the underestimation caused by the coarse spatial resolution of the LANDSAT MSS system.

RESULTS

The corrected acreages of water bodies as determined by the linear combination of spectral signatures in the manner described in the previous section, are very close to the actual acreages as determined by conventional gauging methods.

At the present time a statistical analysis is being conducted to test this correction procedure using 127 water bodies of the state of Indiana. Further conclusions and recommendations will be included in the Final Report.

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Winters, J. 1973. "Indiana Water Resources: Future Problems and Needs." Workshop Proceedings, Water Resources Research Center, Purdue University, W. Lafayette, Indiana. May 1973. 185 pp.

TECHNIQUE DEVELOPMENT

DATA BASE PROJECT

P. Anuta, M. Singer and B. Dahl

INTRODUCTION

The data base project has the goal of applying the techniques of remote sensing augmented by resource data obtained from non-remote sensing sources to problems of resource management in Indiana. The term "data base" refers to an aggregation of resource variables for an area stored in a computer retrievable format with the results of remote sensor data analysis overlayed onto the data base. The composite data set can be used to answer a broad range of questions regarding resources and suitability of these resources for various uses. Technology has been developed and application to test problems within the State is underway.

STATUS OF DATA BASE TECHNOLOGY

Software for creating and interacting with a high dimensionality grid cell data base has been developed and tested over the past year. The capabilities include procedures for registering the results of remote sensing data classification onto a data base grid. Techniques for digitizing and gridding resource and topographic maps have been developed. Flexible output format capabilities have been added to enable color film and map separation transparencies to be made from data base output files. The current system allows users to specify single or combination of variable outputs via logical functions.

Several examples of data base output are included here to illustrate the current capabilities. An example data base was assembled over a ten by fourteen kilometer area in eastern Tippecanoe County, Indiana. All variables were manually input except the LANDSAT surface cover classification which was automatically registered onto the data base. The grid cell size is 1/10 kilometer on a side or one hectare in area. Figure 1 contains an output image from the data base for the highway transportation variable. Figure 2 is an output image showing zoning coded in color in the original and reproduced in black and white here. The meaning of the gray levels is listed in the figures. Figure 3 shows the overlayed LANDSAT classification which supplies information on land use and cover including forest, agriculture, water built-up and grass or pasture. Figure 4 is a logical output from the data base for residential suitability. The data base was asked what points were most suitable for residential use based on soil characteristics, transportation, zoning and others. Areas along the roads came out as most suitable and areas in flood plains were labeled undesirable. These examples are presented to illustrate the type of output intended. The color coded products would be reproduced at map scales with map coordinate overlays for use by planning agencies.

APPLICATIONS ACTIVITIES

Two data base applications activities are being pursued in support of land use planning activities in the State of Indiana. One is well along and the other is still in the planning stage. The first activity is being conducted in support of the Town Planning Board of Yorktown, Indiana in Delaware County (Attachment 1). An area of six square miles is being studied at a grid cell size of one half acre.

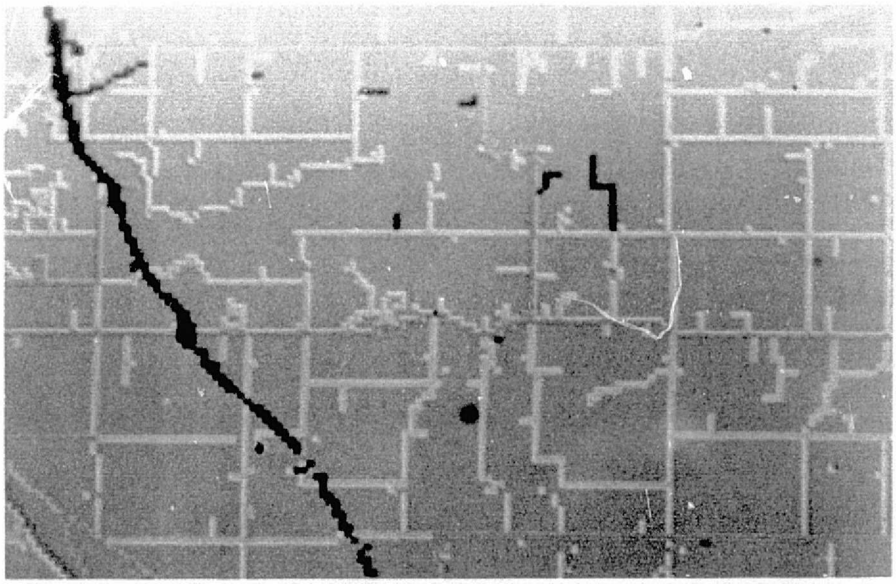


Figure 1. Road Transportation Output From Data Base Light Gray - Medium Duty, Dark Gray - Light Duty.

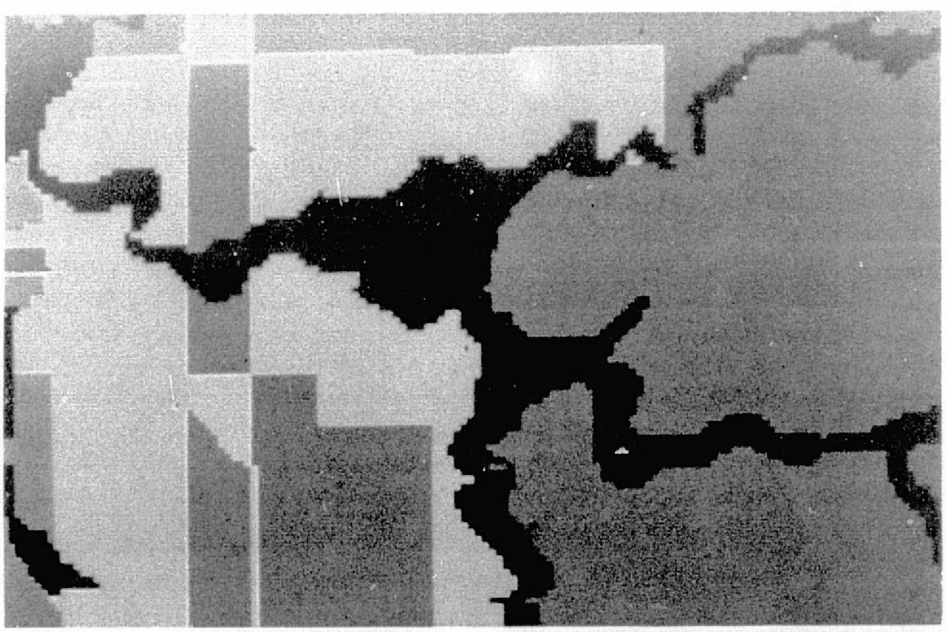


Figure 2. Zoning Output. Light - No Zoning, Medium - Residential, Dark - Conservation.

ERRATA

The captions for figures 1, 2, 3, and 4 on pages 36 and 37 should read:

Figure 1. Road Transportation Output from Data Base. Light Gray - Medium Duty, Medium Gray - Light Duty, Black - Heavy Duty (The dark segments in the upper center area are private lanes.)

Figure 2. Zoning Output. Light - Residential, Medium - No Zoning, Dark - Conservation

Figure 3. LANDSAT Classification Overlayed on Data Base. White - Pasture, Light Gray - Wet or Flooded Soil, Medium Gray - Agriculture, Dark Gray - Forest, Black - Residential/Commercial

Figure 4. Logical Output from Data Base for Residential Suitability. White - Marginal, Light Gray - Undesirable, Medium Gray - Satisfactory, Black - Desirable

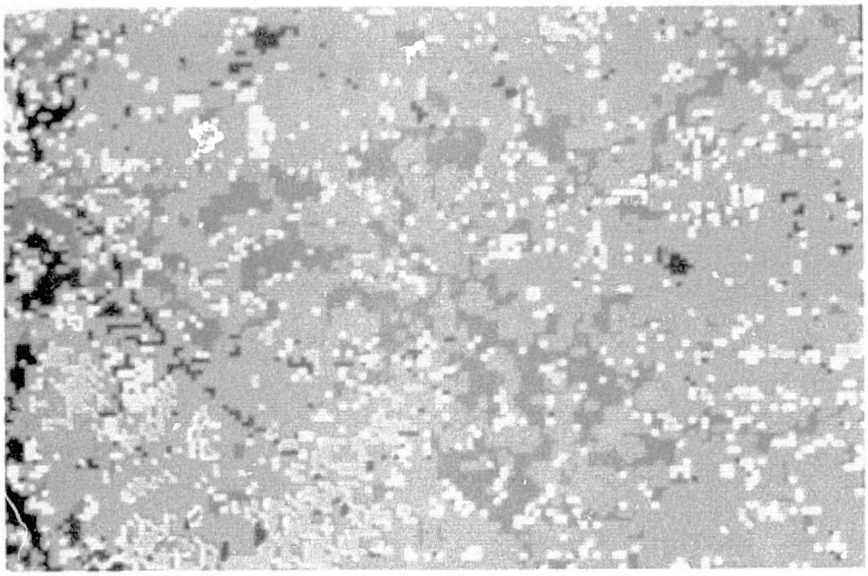


Figure 3. LANDSAT Classification Overlayed On Data Base. Light - Agriculture, Medium Gray - Water, Urban, Dark - Forest.

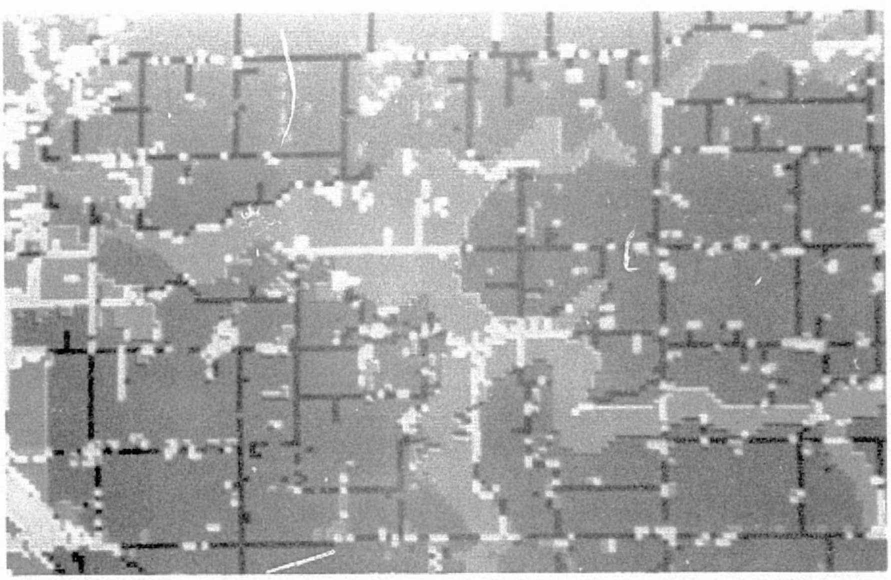


Figure 4. Logical Output From Data Base For Residential Suitability. Light - Undesirable, Medium Gray - Marginal, Dark - Desirable Areas.

The variables being digitized are soils, topography, zoning, land use and well records. There are nine soil parameters and data from over 50 wells will be used. The well data includes depth to first sand, percent unconsolidated material and depth to bedrock. Remote sensing data will be used to aid in defining land use. The data base will be used to aid in making zoning change decisions and in formulating land use plans for the future by the Town Board and possibly the Delaware County Planning Commission.

Much of the work on this project was conducted by Dr. Harlan Roepke, Associate Professor of Geography while on sabbatical leave from Ball State University. His contributions were a direct result of a research project which led to Dr. Roepke's obtaining an M.S. degree in Geology. A copy of his research report is available upon request.

The second activity is directed toward the Indiana Heartland Coordinating Commission which has responsibility for planning and administering land use and water quality legislation for Region 8 which includes Marion County (Indianapolis) and the seven surrounding counties. A data base for portions of this area is proposed. The total area covers 60 by 60 miles and a one hectare grid cell is proposed with variables including soils, topography, land use, geology, zoning, transportation and population density. Remote sensing would aid in supplying soils and land use data.

A meeting between LARS personnel and a majority of the staff of the IHCC on October 21, 1975 was held, and information was exchanged on the plans and desires of both parties with respect to the data base. The Zionsville area in Southeastern Boone County emerged as an area of particular interest, and data collection has begun. Geological and topographic data will be digitized first. A LANDSAT classification of the area was done previously, and this will be inspected for suitability for land use input.

CONCLUSIONS

A data base generation, manipulation and output product generation system has been developed with LANDSAT remote sensing data potentially providing land use and soils data. Applications of the techniques to Delaware and Boone County, Indiana planning problems have begun and evaluation and use of products from the system is expected by June 1976.

The NEWS
Yorktown, Indiana
Friday, June 13, 1975

Computerized land use studies are a possibility for Yorktown

Casey Flick, Yorktown Town Board President, has announced a special joint meeting of the Town Board, the Board of Zoning Appeals, and the Plan Commission for 7:30 p.m. Monday, June 16, at Town Hall with representatives of the Laboratory for Applications of Remote Sensing (LARS).

Flick said Purdue professors Bernie Dahl and Hal Roepke would explain the program. The meeting may be rescheduled if the professors are unable to come to Yorktown that night, added Flick.

LARS representatives will explain a plan through which the town could obtain computer analysis of land use data for guidance in making policy at minimal cost to the town. Sound planning has been a universally recognized need of late, considering the rapid growth rate of Yorktown, and Flick said that the LARS system could help town planners at no cost other than the fee imposed for renting computer time.

In its official proposal to the Town, LARS proposed to:

(1) Assemble and store in computer data files all available information having geographic variations (for example; soil types, present land use, land ownership, flood-pronc areas). The choice of types and courses of information to be compiled is to be guided by the goals and needs recognized by the Town Board, and discussed with the LARS representatives.

(2) Print out the data files in map form, illustrating the geographic distribution of the data values.

(3) Select several types of information and combine them to create maps which show the distribution of areas that are suitable for certain specified uses such as landfill sites, residential septic systems, sand and gravel pits or maps that show other properties such as agricultural productivity.

(4) Make available to the Town Board the data files together with information on how to update the files and how to combine the information in new ways to produce new maps as the needs of the town change.

Several planning and policy decisions will be addressed by the Town Board in the near future. It is desireable to have the subjects of these decisions identified and the kinds of information useful in resolving them listed, in order to determine what kinds of suitability maps or other data combinations are most needed.

It is proposed that the Yorktown Town Board meet with the LARS representatives to guide them in choosing the important items of information to be compiled and used. These meetings should be conducted as soon as practical, preferably in June, 1975.

It is intended that the majority if not all of the data files, the computer program for manipulation and display of the information, and the users guide will be completed by August, 1975. It is therefore further proposed that there be a demonstration of the system to the Town Board in August.

In return for providing the Yorktown Town Board with the information described, LARS and the agencies that are funding this experiment request that the Yorktown Town Board use the information system in the formulation or evaluation of one or more ordinances or other resolution on which the Board rendered a decision, and that a brief report be written describing how the information affected the decision.

EVALUATION OF GRAVEL DEPOSITS USING REMOTE SENSING DATA, WABASH RIVER VALLEY NORTH OF TERRE HAUTE, INDIANA

T. R. West and S. A. Mundy

INTRODUCTION

Gravel deposits which can be processed economically for construction materials are an important material resource despite their low unit price. Although gravel is not a rare geologic material, owing to the large quantities consumed by construction and its high cost of transportation relative to unit value, a gravel supply must be located relatively close to market for it to have commercial value. Such a material is said to have a high "place value."[1]

Because of these considerations, a maximum hauling distance of only several miles is allowed for competitive pricing. To complicate the problem further, gravel is needed close to urban centers where the majority of construction occurs. As urbanization spreads from population centers gravel-rich areas are commonly covered over by housing tracts which obviously precludes gravel extraction at that site. In addition as urbanization of an area proceeds, operating gravel pits locally suffer political pressure to minimize their environmental impact (noise, dust, traffic, etc.) which acts as a deterrent to continued gravel production and future pit expansion.

Economics in Indiana dictate that a viable gravel-extraction operation have a 20-year supply of material and based on a reasonably small extraction of 200,000 tons per year, an area of some 80 acres is needed.[2] For smaller, short term projects such as highway construction in a rural area, much smaller volumes of gravel may prove economical to work. Also with the steady approach of urbanization in an area, pits only 10 acres in size operating for a two-year period may prove both economical and necessary.

The economic impact of gravel production in Indiana is significant. Table 1 indicates that 1973 sand and gravel production had a value of nearly $37 million for 11% of the state's mineral production for that year. This is based on information published by the U.S. Bureau of Mines.[3] A volume of some 28 million tons of sand and gravel was produced in 1973 at an average value of $1.30 per ton. Obviously, the total value of gravel production is significantly greater in many of the more populous states and in some areas a shortage of these construction materials exist. This is borne out by the fact that the Federal Highway Administration, U.S. Department of Transportation, has recently solicited research proposals on the use of airborne geophysical techniques for the purpose of locating construction materials.[4]

Because of the increasing demand for construction materials, the loss of gravel extraction sites due to urban sprawl and the high place value of gravel deposits, it has become necessary for gravel producers to increase their exploration efforts to locate new sources. Cost of exploration for an 80-acre site is estimated at $1200 to $1750 using conventional drilling augmented by subsurface geophysical techniques.[2] With these comparative costs in mind, it is apparent that if remote sensing analysis can reduce the expenditures for

Table 1. Gravel Production in Indiana

Year	Total Value of Indiana's Mineral Production ($1000's)	Total Value of Indiana's Sand & Gravel Production ($1000's)	Total Sand and Gravel (1000's of short tons)	Value of Sand and Gravel as % of Value of Mineral Production
1963	202,530	20,683	22,840	10.2
1964	211,783	21,811	24,416	10.3
1965	218,567	22,220	24,867	10.1
1966	230,010	23,542	24,992	10.2
1967	244,921	25,588	26,265	10.4
1968	235,386	26,160	25,774	11.1
1969	241,871	27,438	26,218	11.3
1970	228,786	25,796	23,476	11.3
1971	281,521	29,094	24,982	10.3
1972	322,608	33,290	27,978	10.3
1973	340,915	36,734	28,257	10.7

exploration in an area by designating prime areas for detailed study, a valuable contribution can be made.

SETTING OBJECTIVES

A test site north of Terre Haute in Vigo County, Indiana was recommended for study by the Indiana Geological Survey. Figure 1 is a locations map for the site. This study to locate gravel supplies using remote sensing techniques was selected by LARS and the Indiana Geological Survey as a significant topic related to the needs of Indiana, the conclusions of which would influence decision making relative to mineral exploration and land use planning. LARS would provide the analysis of the remote sensing data, and the Indiana Survey would provide basic geologic information during the study and geologic evaluation of the findings.

The study site is a river terrace on opposite sides of the Wabash River and immediately north of Terre Haute. The bedrock valley of the Wabash River was filled with more than 100 feet of sand and gravel which was deposited as glacial melt-water began to diminish. Such deposits are termed glacial outwash. The surface of this deposit in the Wabash Valley is known as the Shelbyville Terrace, and it lies about 75 feet above the present Wabash River with the river at an elevation of 460 feet.

Massive glaciers advanced into Indiana at least three times during the Pleistocene. The earlier invasions extended far south of Vigo County, and the last ice sheet halted just to the north of Terre Haute. Each glacier deposited till from the ice and also produced large quantities of sand and gravel-bearing outwash. In a meandering stream, such as the present-day Wabash, the coarsest gravel is deposited on the insides of the bends, and it builds toward the center of the channel along bars. However, a glacial melt-water stream, which is highly charged with sediment, deposits the coarse material within the center of a broad flat, braided channel in the form of diamond-shaped bars that are elongated in the direction of flow.

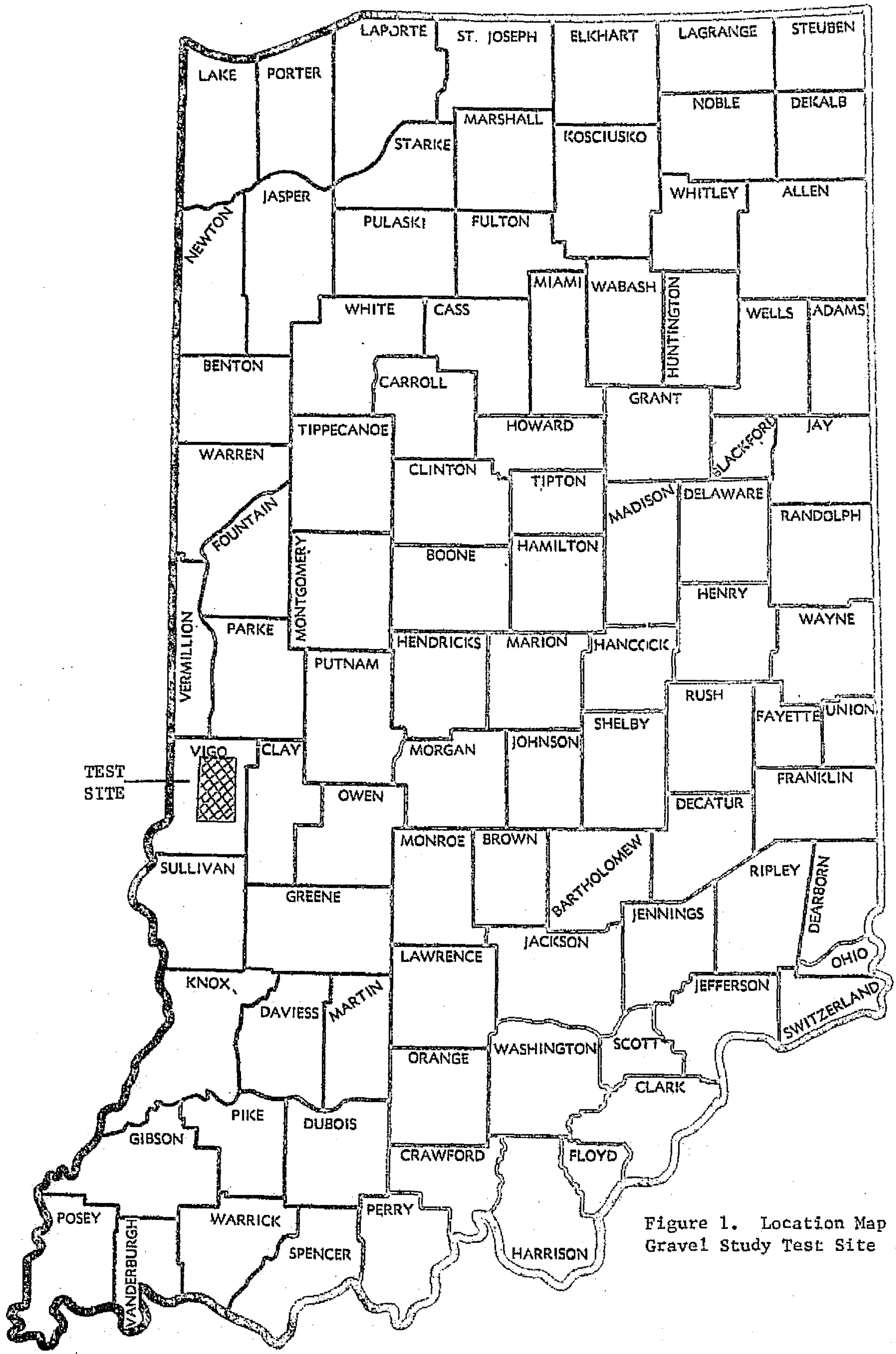


Figure 1. Location Map of Gravel Study Test Site

In this study the primary objective was not merely to locate sandy materials which hopefully contain some gravel because it was already established that essentially all the Shelbyville Terrace at Terre Haute has some gravel present. Also, the area of study was fairly large (approximately 40 square miles), and about one-half of it consisted of the upland terrace. Instead, the purpose was to find locations within the terrace that possessed high concentrations of gravel, those places where gravel could be extracted at a profit. The proportion of gravel necessary to make a pit economical varies with the intended use of the gravel and the market for the remaining sand. Generally for Indiana, few pits operate with less than 25% of the material being larger than 3/8" in diameter. Pits with 80% sand containing a good masonry sand or with a market for large volumes of fill sand, however, do operate at a profit. Therefore, it was concluded that locating deposits with a minimum of 20-25% gravel (larger than 3/8" material) would be the objective of this analysis.

PROCEDURE

The primary remote sensing data used in the analysis consisted of three sets of LANDSAT imagery obtained during the months of January, June and September 1973. Previously, these data had been geometrically corrected and the imagery for the three LANDSAT passes overlaid to provide a single, twelve channel data tape. This combined data tape had provided the basis for land use mapping of Vigo County.[5]

In addition to the LANDSAT data, high altitude (60,000') 9" infrared photography of Vigo County, 1:120,000 scale flown in May 1971 was also available at LARS. A surface geology map of the area north of Terre Haute was provided by the Indiana Geological Survey. This map represented the area covered by the Rosedale and New Goshen 7½ minute (1:24,000 scale) topographic quadrangle maps. A smaller scale somewhat generalized map based on that surface geology information is presented as Figure 2. Eight known gravel-extraction operations, whose locations were supplied by the Indiana Geological Survey, were positioned on the quadrangle maps.

The first step was to locate Terre Haute and the area north of it on the LANDSAT data tape. This was accomplished using the visual display unit at LARS and recognizing the features of the Wabash River and adjacent drainage patterns. The 1:60,000 scale infrared photography was extremely helpful in outlining the area of study on the LANDSAT imagery.

After the study area of 108 lines x 116 columns was designated in the LANDSAT data an attempt was made to determine surface features distinctive of gravel deposits. Possible distinctive features considered were vegetative cover, drainage pattern, soil cover, or temporal changes in these features in the January, June and September imagery. If distinctive features of gravel deposits were found, a unique, spectral signature of these deposits could be isolated through computer-assisted analysis. Figures 3a, 3b, and 3c show the variations between season in the terrace area near the center of these three images as depicted on the visual display unit using filters to simulate a false color rendering of the spectral response. It can be observed that the colors in the terrace area change with season and that, indeed, a variation of pattern within the terrace area at all seasons does exist. This observation provided encouragement as the LANDSAT spectral data apparently provided significant detail for the study purposes.

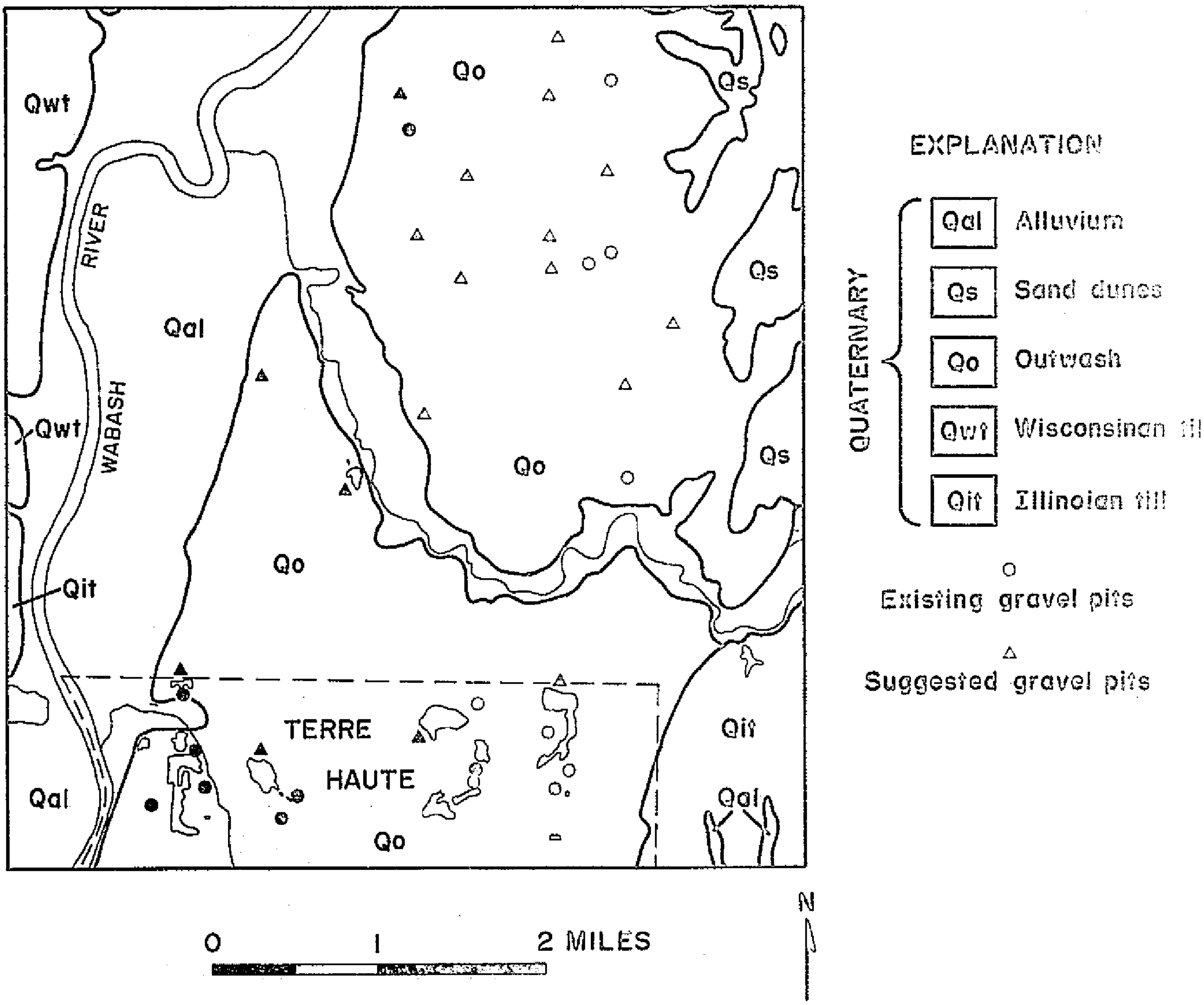
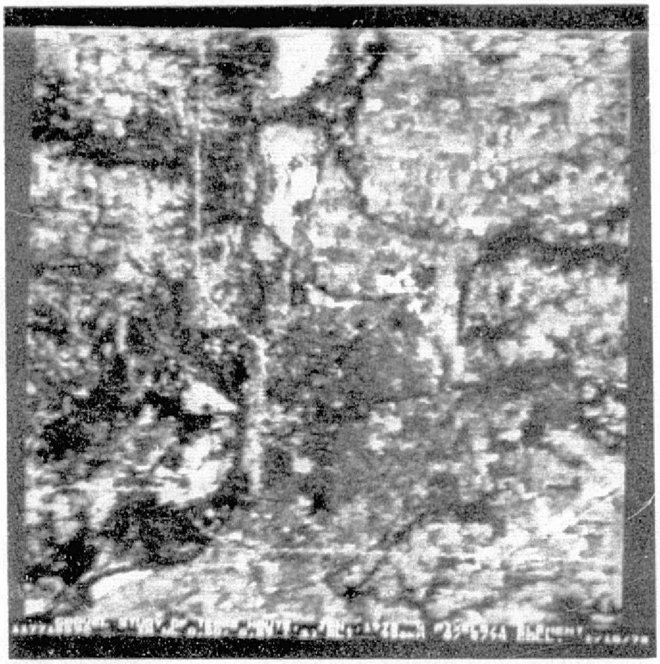


Figure 2. Surface Geology Map of Area North of Terre Haute, Indiana



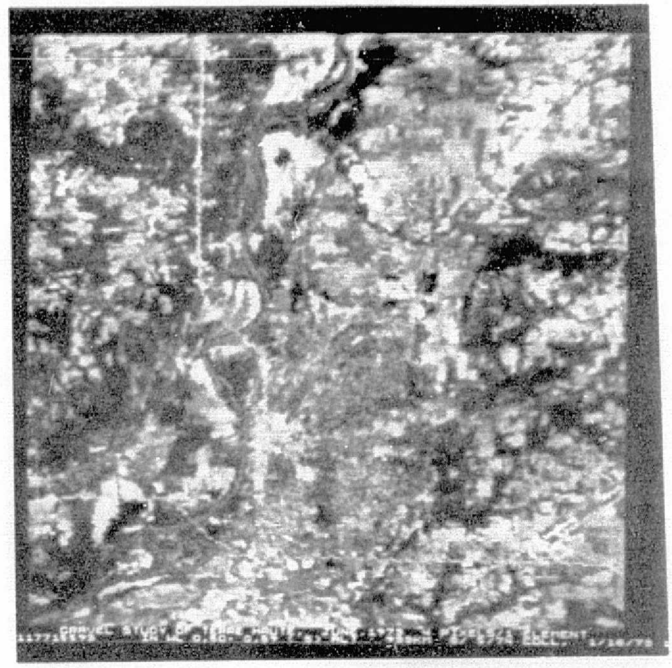
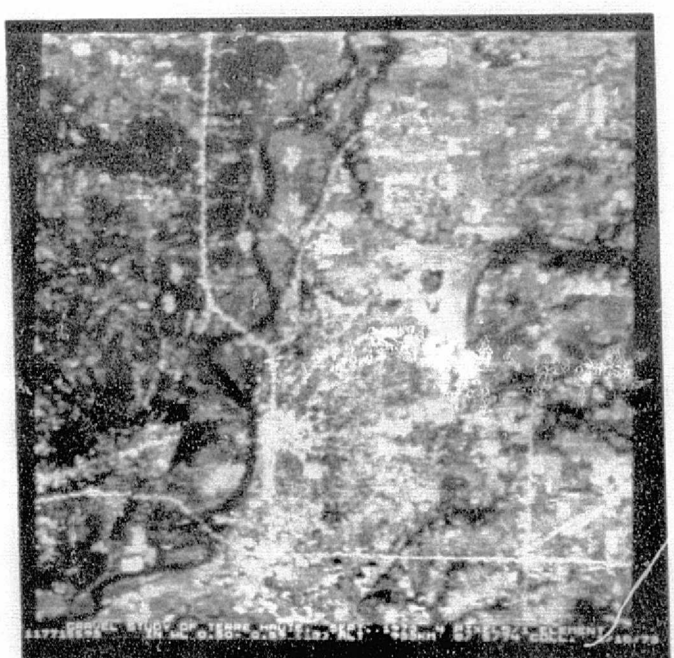


Figure 3

Digital display
January, June, and September 1973 Data



The first computer-assisted analysis of the data involved a non-supervised or clustering approach. In this analysis, the computer subdivides the spectral data into groups or clusters according to spectral similarity. Seven spectral classes were specified with each data point assigned to that cluster class of the seven showing the greatest similarity. Thus, water might be one class, vegetative cover another, along with bare soil, etc. comprising other classes. Clustering was performed on the January, June, and September portions individually and also on the combined, overlay tape consisting of all twelve channels of data. If a unique gravel class should exist, this classification in all likelihood would point it out.

The second computer-assisted analysis involved the supervised approach. In this situation, the computer is trained to recognize a specific signature of known materials which are outlined for it in the data. Based on the statistics of the designated area (means, standard deviation) and applying a Gaussian probability distribution, points with similar statistical descriptions are located in other portions of the study area. To train the computer for this purpose, eight sites of present or recently abandoned gravel operations were designated. Each site was one or two acres in size, and it was concluded that each was located in the LANDSAT data within the accuracy of one to two resolution elements (pixels). As these gravel deposits are known to be larger than one acre and because of the problem in location accuracy, each site was represented by nine pixels, the central one plus its eight surrounding, nearest neighbors. Also, ten pixels correspond to an area of about eleven acres which is about the minimum size of an economically feasible gravel extraction site, even in a suburban area.

Using the eight known gravel areas as training sites for the computer, the entire area was classified. As only one training class was considered, the entire study area must fall into this single class; but to insure that only the most similar materials would persist, a considerable threshold of 75% was applied to the classification. Thresholding in effect deletes the tails of the Gaussian distribution which in this case leaves only 25%, the central portion of the distribution remaining. This classification was performed using the individual LANDSAT frames for the three seasons plus the combined twelve-channel data tape. Despite the severe curtailment by thresholding, much of the study area was still designated to be within the gravel class.

CLASSIFICATION RESULTS AND FIELD EVALUATION

The supervised approach described in the previous paragraphs did not accomplish the desired results. On all three of the one-season LANDSAT frames, more than half of the total area received the gravel designation despite the 75% threshold. This classification obviously did not discriminate the areas with high gravel content or even those composed predominantly of sand and gravel as portions of the floodplain and ground moraine as well as the terrace were included in the gravel class. The supervised classification of the twelve channel overlay of these three frames, however, yielded better results although it did not single out areas of high gravel content. Instead, it outlined quite well the entire sand-gravel terrace area (Shelbyville Terrace) excluding the landforms composed of finer textured soils (floodplain and ground moraine). Even though it did not accomplish the desired result of locating high-gravel content areas within the terrace, it did demonstrate that coarse textured materials could be distinguished from fine textured ones using the classification of overlay data.

The non-supervised (cluster) analysis proved more successful than the supervised one. Seven cluster classes were used to cluster the three LANDSAT frames and the 12-channel overlay combination. As with the supervised classification, the 12-channel overlay data yielded better results. On all four classifications the existing gravel pit locations obtained a common symbol which also coincided with the area adjacent to the Wabash River. Apparently the high moisture area of gravel cluster was singled out for review (designated by T in Figure 4). Logically this class should have the least chance of indicating a gravel rich area. Seven sites were designated in the terrace deposit where the T cluster symbol was present, and a map showing these locations was forwarded to the Indiana Geological Survey. Owing to a number of complicating factors including severe weather conditions followed by heavy scheduling of the drilling equipment and several mechanical problems, the seven sites were not drilled until September 17, 1975 (Holes 176-182). The results in general seemed to show that gravel did not occur within the upper 8 feet to as great an extent as it did in the first series of holes.

The evaluation of gravel content in the drilled holes is somewhat subjective as the materials were sampled from a continuous flight auger drill which is far from ideal for sampling sand and gravel materials. Also holes 173, 174 and 179 had the coarsest material throughout the total section drilled. Only hole 172 of the "gravel-rich" designated areas had little gravel present whereas the other three did have gravel (173-175) with 173 and 174 quite rich in gravel. By contrast only hole 179 of the "gravel-poor) sites (176-182) had significant gravel and this was below a clayey, surface material.

CONCLUSIONS

From this study it is concluded that the non-supervised classification of the LANDSAT 12-channel overlay data designated reasonably well those areas with a high probability of finding gravel-rich zones near the surface. The supervised classification was also able to designate the broad categories of coarse textured soils (here terrace deposits) from other fine textured soil areas (floodplain and ground moraine).

It is concluded that this technique along with available geologic, agricultural soils and photographic information can be used to locate areas with a higher potential for gravel deposits of an economic value. For further refinement field studies using the electrical resistivity method and subsequent subsurface drilling can be performed in the areas designated as gravel-rich.

Dark areas - suggested sites with high-gravel percentages
Symbol T - suggested sites with low-gravel percentages

Figure 4. Non-supervised classification of 12 channel overlay of LANDSAT data, January, June, and September 1973

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DEMONSTRATION PROJECTS

SOIL INVENTORY PROJECT

C. Walker, F. Kirschner, O. Montgomery and R. Weismiller

INTRODUCTION

During the past 6 months, members of the LARS staff have been collaborating with the USDA/Soil Conservation Service (SCS) in Indiana to develop and evaluate remote sensing techniques as an aid in soil survey. It was proposed in the statement of work for FY76 that LANDSAT data be used as an additional source of reference data for detailed soil mapping. In discussions with State Soil Scientist Ray Sinclair, it was proposed that satellite MSS data be incorporated into the soil mapping program at three levels.

1. To provide a broad view of the landscape and soils differences for initial planning of the survey;
2. To aid in determination of the broad range of soils and in the preparation of the descriptive legend prior to the initiation of detailed mapping;
3. To provide detailed alphanumeric printouts (spectral soils maps) at the same scale as the aerial photographs for use in detailed soils mapping in the field.

STATUS (JASPER COUNTY)

Since a soil survey of Jasper County is scheduled to begin in FY77, this county located in northwestern Indiana was selected for development of the first level of the soil mapping program. The project will begin with the initial review at which time a reconnaissance survey will be conducted. A reconnaissance survey provides an overview of the soils that are found within a county. At present, sampling sites are selected by studying surveys from surrounding areas and information derived from general soil maps. A tentative descriptive legend of the soils of the county based on the samples of the soils obtained from the reconnaissance survey is prepared.

LANDSAT data collected 9 June 1973 are being analyzed for incorporation into the reconnaissance survey. Mr. Sinclair believes that the synoptic view from satellite altitude will provide information about the soils which has been unavailable in the past. Important information to be derived from satellite imagery includes:

1. Broad relationships between soils and their physiographic positions;
2. Complexity or degree of homogeneity of the soils as they appear in the landscape;
3. Indications of areas requiring extensive sampling during the reconnaissance survey;
4. Delineation and composition of soil complexes;
5. More adequate and detailed descriptive legends.

To achieve the required objectives, LANDSAT data are being utilized in two forms. First, false color images of the data for visual analysis are produced. From these images and associated general soil maps, broad soil categories (associations) are delineated and related to different parent materials. Using these delineations as guides for separating soils, sites are selected for digital processing.

Seven areas have been selected for cluster analysis to study the spectral characteristics of the soils in each association. Separate cluster maps for each of the seven areas were produced. Addresses of the cluster areas were located on maps and aerial photographs and are currently being field checked.

To date two of the seven cluster sites have been field checked. The first area was located in the northern part of the county where the predominant soils were developed from outwash or lake deposited sands. They are commonly subjected to a seasonally high water table and most are poorly drained.

An alphanumeric map of this area (Figure 1) has been checked in the field by identifying the soils that were separated spectrally on the printout.

The areas represented as A are poorly drained Rensselaer and Gilford soils. These soils are similar in color and surface texture but are in different families. Rensselaer is in the fine-loamy family and Gilford is a member of coarse loamy family. The cluster map shows this area as being represented by two symbols, "M" and "$." Results of spectral analysis indicate that the M's are Gilford and the $'s Rensselaer. More sampling, however, will be required to substantiate this interpretation.

The areas represented by B are Milford soils. Milford is a dark (10YR2/1) soil similar to the Gilford and Rensselaer but being in the fine family. No significance has been attached as yet to why two symbols "*" and "E" are appearing for the Milford. The information obtained from the separability processor indicates that these two classes are spectrally similar.

Areas C and D checked out as Plainfield soils. Area C is Plainfield with a vegetative cover while D is bare soil. Plainfield soils are sandy soils formed in dunes or sand ridges. They are light colored (10YR4/3) and excessively well drained.

The second region which has been field checked includes glacial till soils in the southern portion of the county.

Preliminary studies have tentatively established that, in this typical till plain area comprised of the Parr, Corwin, O'dell and Chalmers series, the patterns obtained from the alphanumeric printouts are accurate and meaningful. This is especially significant since all the soils in this group are Mollisols and all have dark surface horizons. The differences between the spectral maps for these soils is due primarily to the natural drainage of the soil. Drainage characteristics range from well drained to poorly drained.

In the alphanumeric printout the cluster map for the till area provides five spectrally separable classes (Figure 2). A represents the poorly drained Chalmers, B the somewhat poorly drained O'dell, C the vegetated areas of Corwin, D the well drained Parr and E the eroded areas of Corwin.

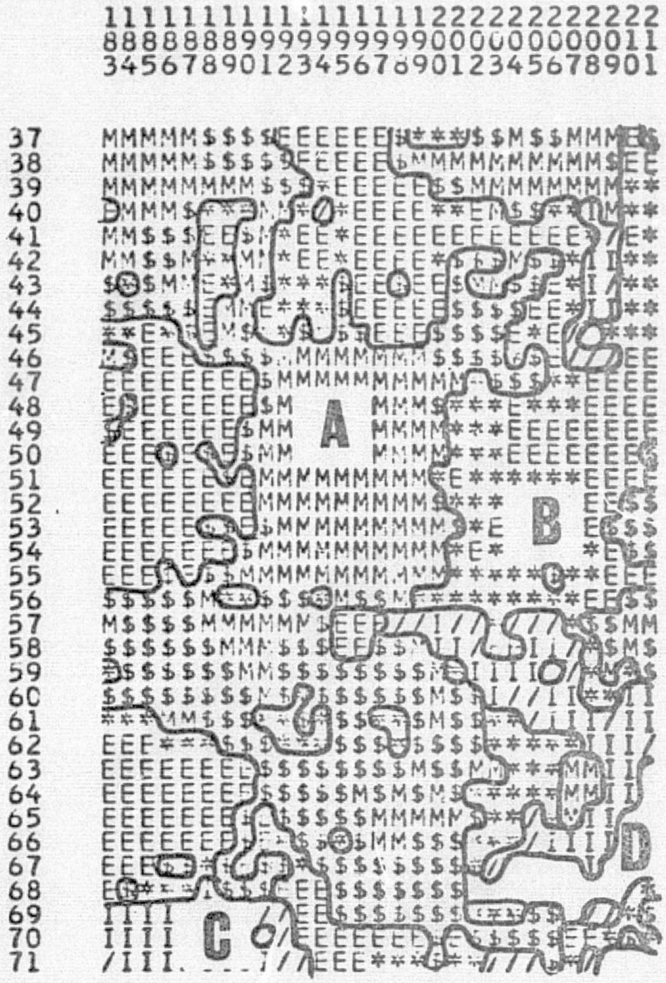


Figure 1. Cluster Area 1, Outwash and/or Lake Deposited Sands.

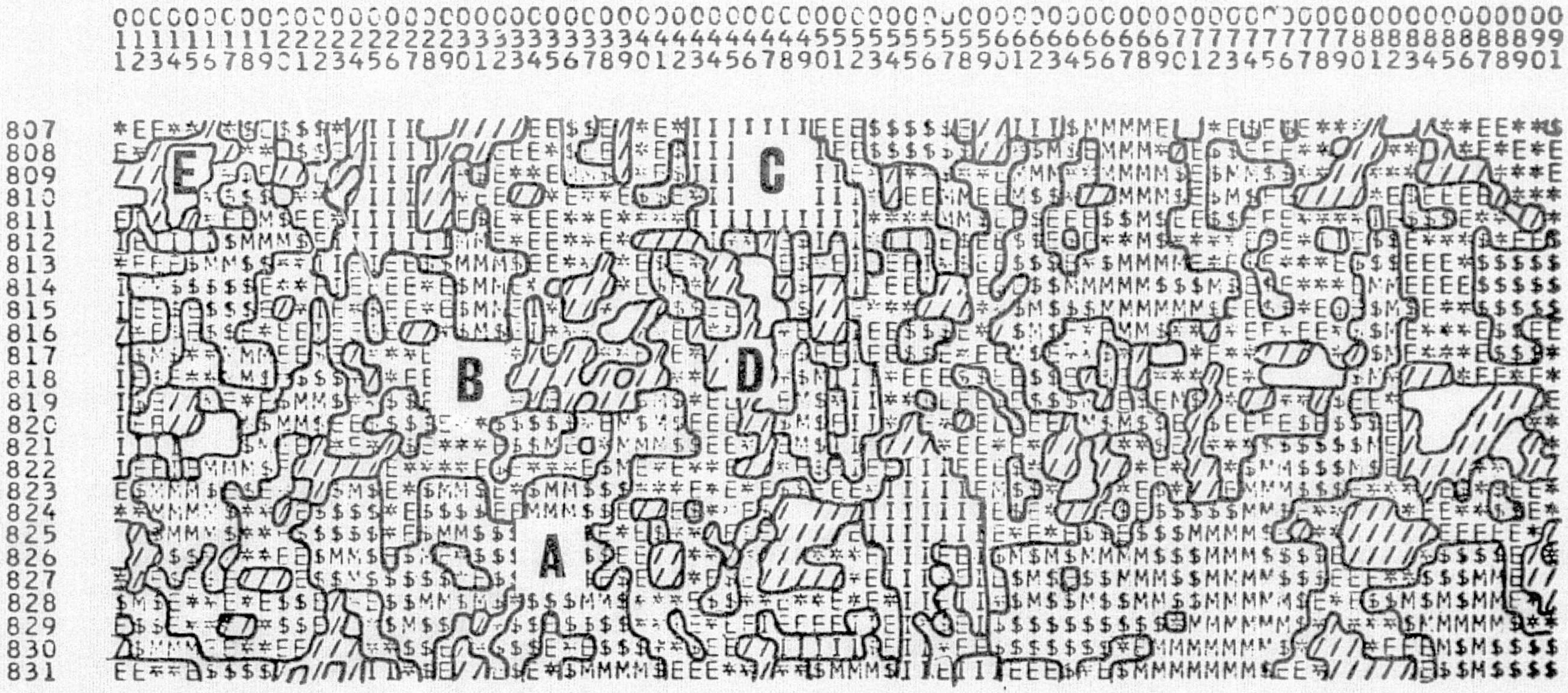


Figure 2. Cluster Area, Glacial Till.

The remaining areas to be field checked are samples representing additional soil complexes and physiographic positions. When all the sites have been checked, the statistics from all the areas will be merged and a soils map based on spectral properties will be produced. Thresholding in the preparation of the soils map will be used to determine if any spectral data points or clusters in the scene have not been identified. If threshold areas occur, samples will be taken from these areas and new statistics generated from which a new classification will be produced.

A descriptive legend of the soils of Jasper County will be written for the soils which have been separated spectrally from digital data. This will complete one of the major steps involved in the initial review. Areas of soil complexes can also be separated at this time using the alphanumeric printouts.

STATUS (CLINTON COUNTY)

Clinton County, located in west central Indiana, is the site currently being utilized for the detailed mapping study. The initial review for Clinton County has been completed and detailed mapping is underway by USDA/SCS personnel. Initial interest in Clinton County was stimulated by research done on delineation of the boundaries of a buried pre-glacial valley (LARS Information Note 100175). Upon investigation of this area, it was found that the soils in the valley were from a different order than the soils of the surrounding area. After consultation with Ray Sinclair, State Soil Scientist and Bill Hosteter, SCS party chief for the Clinton County soil survey project, it was decided to produce alphanumeric spectral printouts of Clinton County at a scale of 1:20,000 from LANDSAT data. These alphanumeric printouts will be used in conjunction with the aerial photographs to delineate soil boundaries. Preliminary field work with LANDSAT data was conducted during October to familiarize the soil survey staff with the spectral map output. Spectral maps will be used in the survey beginning in the Spring of 1976.

To help direct the research in soil survey, the SCS has assigned an experienced soil scientist, Frank Kirschner, to work at the LARS facility for one year. Mr. Kirschner is currently working on the development of the descriptive legend for the soils of Jasper County based upon MSS data.

ACTIVITIES FOR NEXT SIX MONTHS

During the next six months, much of the work on the descriptive legend and reconnaissance survey using satellite data will be completed. Additional field checking of cluster sites to determine mapping unit composition will be completed for Jasper County.

After the completion of the field checking, several areas will be selected to study the utility of satellite data for the soil surveyor. The comparison will consist of three trials and the mapping time required for each method will be noted. The three trials will be set up as follows:

(1) Mapping soils by conventional methods using aerial photography only;

(2) Soil mapping utilizing satellite data only;

(3) Mapping using a combination of aerial photography and satellite data.

These trials will be run on several areas of varying complexity. A soil scientist from USDA/SCS will do the conventional mapping independent of the other methods. Results to date suggest that the third method will provide the most information and the most accurate and meaningful soils map.

FORESTRY DEMONSTRATION PROGRAM

R. P. Mroczynski and J. Berkebile

BACKGROUND

Introduction

During March, 1975, LARS staff contacted the Supervisor of the Wayne-Hoosier National Forest headquartered in Bedford, Indiana. An invitation was extended to the Supervisor and his staff to visit the LARS facility and review the current capabilities in computer-aided analysis of remote sensor data.

A review was held in early April, at which time the Supervisor requested that LARS attempt a land use classification of the Brownstown Ranger District. The classification was to be done with one of seven dates of LANDSAT-1 data available over the area. The Supervisor's staff was interested in comparing LARS analysis results with a land use classification it had just completed using conventional methods. This request marked the inauguration of LARS' forestry demonstration in Indiana.

Historic Background of Hoosier National Forest

The Hoosier National Forest dates its beginning to January 21, 1935. On this date the National Forest Reservation Commission approved the establishment of three National Forest Purchase Units in southern Indiana. The original Purchase Units which included parts of nine counties consisted of a gross area of 781,320 acres.

The Indiana and Ohio Purchase Units were combined, because of economic necessity, in 1949. The administrative headquarters was located at Bedford, Indiana, and the combined units were called the Wayne-Hoosier Purchase Units. On September 4, 1951, the Indiana units were combined to become the Hoosier National Forest.

The 1974 ownership statistics indicated that 645,042 acres are included within the Hoosier National Forest boundaries. Of this total acreage 117,289 acres are National Forest lands, while the balance is in other federal, state, or private ownership. Figure 1 indicates the approximate forest boundary in Indiana.

Resources of the Hoosier National Forest

Hardwoods represent the predominant timber types in the Central States Region of the U.S. For timber classification purposes, there are two types mapped on the Hoosier National Forest, hardwoods and planted pine. Oak-hickory is the predominant hardwood type and total growing stock volume is composed of white and other oaks, hickory, pine, and tulip poplar.

Approximately 118,500 acres of the Hoosier are regulated or managed for timber production purposes. Only 6% of this area is considered poorly stocked

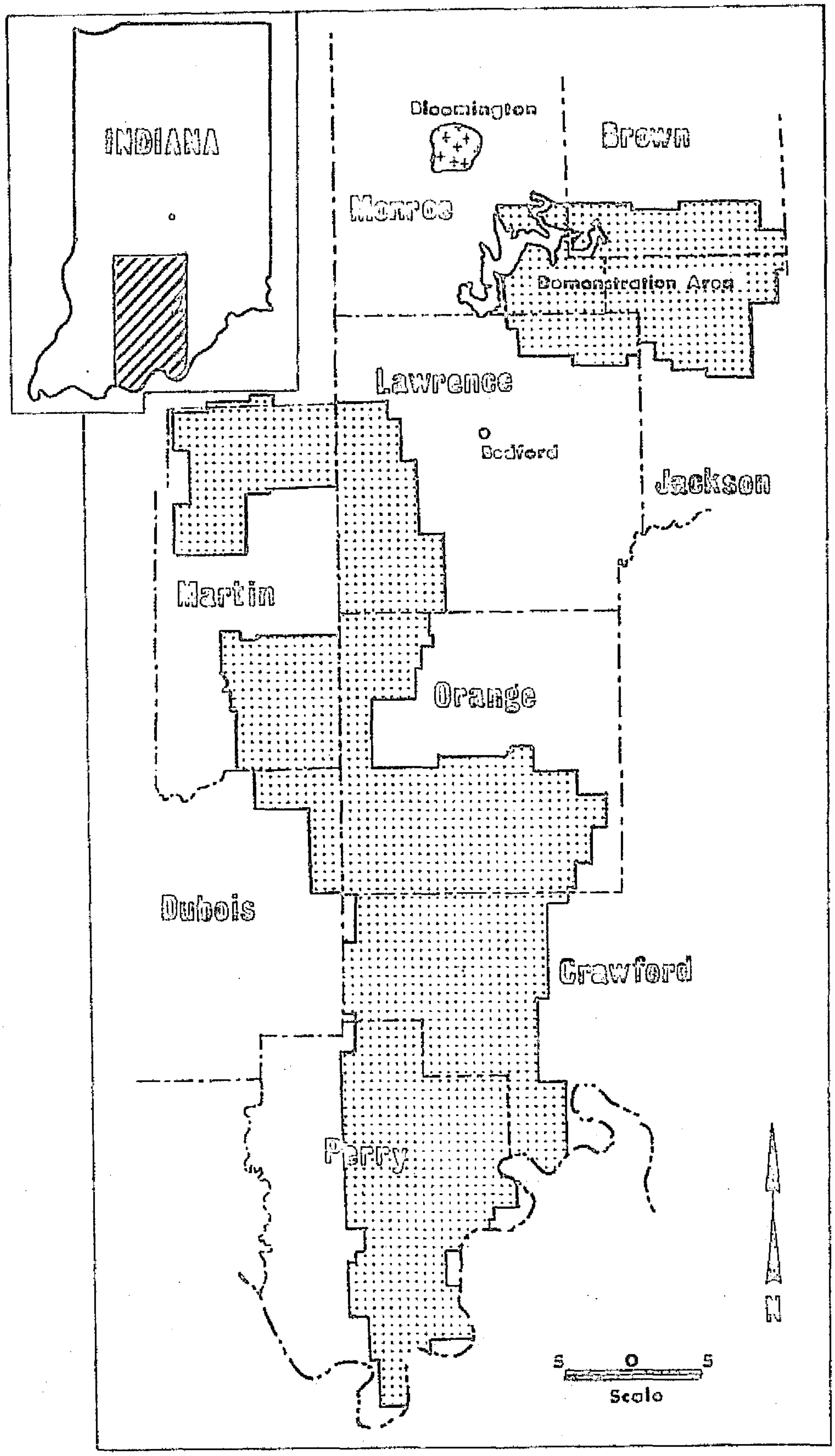


Figure 1. General forest ownership boundary of the Hoosier National Forest.

or non-stocked. Total estimated growing stock is in excess of of 168,000 cubic feet; 94% of this total is in hardwood volume and 6% in softwood. Distribution of area by size class is approximately 56% in saw timber and old growth stands, 24% in pole timber and the remainder in seedling-sapling-open areas.

PROJECT STATUS

Objective

The specific objective for this task has been developed by personnel from both LARS and the Forest Service. The objective is:

> To apply computer-aided analysis of LANDSAT multispectral scanner data for the purpose of preparing resource information relevant to the management of central hardwood forests.

In pursuit of this major broad-based objective, the following goals have been identified by the Supervisor's staff of the Hoosier as important milestones:

1. Preparation of general land use maps and acreage estimates,
2. Preparation of timber stand maps and related information, and
3. Identifying, developing, and implementing methods to input and output irregular field boundaries.

The project status matrix, Figure 2, identifies major areas where LARS staff will attempt to demonstrate the feasibility of applying computer-aided technology as an aid to the decision maker. The areas described in the matrix have all been identified by the Supervisor's staff as information necessary to the management of the National Forest. To produce these maps, the LARS staff will group the spectral classes of one or more classifications in various ways to obtain the desired informational categories.

Accomplishments to Date

Land Use Mapping

Initial work on this task was aimed at addressing the first milestone - preparation of a land use map for the Brownstown Ranger District (Northernmost unit in Figure 1). June 8, 1973 (Scene ID: 1320-15541) LANDSAT-1 data was selected for this analysis. Reference data in the form of WB-57 high altitude aerial CIR photography and timber stand information were available over the majority of the Ranger District.

The analysis was designed to match the land use classes identified by the Forest Service. The classes of interest are: water, pasture, cropland, brushland, pine, hardwood, and urban-suburban. The LARS classification output map is shown in Figure 3. The overlay is the land use map prepared by the Forest Service.

The two maps are in general agreement with regard to the distribution of the classes. There are reasonable explanations for the differences that do occur between the maps. In the LARS classification, pasture and agricultural lands have been combined, and there is no urban-suburban class. Pasture and cropland were not classified separately because they did not appear to be spectrally separable in the selected spring date.

PROJECT STATUS MATRIX

WAYNE-HOOSIER NATIONAL FOREST STUDY

Demonstrations	Current Status: Feasible	Important to User	User Defined Objective	Analysis Phase	Evaluation Phase	Application Phase	Application
Timber - Cover type maps - Density class maps - Slope Aspect maps - Change detection	X	X	X	X			Decisions will be made regarding timber production through improved estimates of productivity. Information will also allow better allocation of resources for timber production activities.
Fire - Type maps - Slope Aspect maps - Fire hazard maps - Change detection	X	X	X				Information in these areas will be used to make decisions regarding the size and deployment of fire crews, based on the location of hazardous fire areas.
Wildlife - Cover type maps	X	X	X				This information will be useful in determining habitat diversity and will allow for decisions concerning location of wildlife openings and waterholes.
Planning - Type maps - Data base - Watershed overlays	X	X	X	X			General information as above will help in settling tentative output targets for the forest plan. Watershed information will be useful in locating and protecting impoundments and wetlands.
Land Acquisition	X	X	X	X			General land use maps will be helpful in assessing where parcels of land are and their suitability for acquisition.

Figure 2. The project status matrix indicates which demonstrations have been identified by the Forest Supervisor's staff as important. The matrix also indicates the status of accomplishments for each demonstration.

Figure 3. (Facing Page) The printout and overlay are land use classifications for the Brownstown Ranger District. The overlay was developed from ground survey and photo interpretation. The printout from computer-aided analysis of LANDSAT MSS data.

Map Classes: C=conifer; P=pasture; A=agriculture; U=urban; B=brushland; and the blank= oak-hickory.

Printout Classes: *-conifer; =-ag pasture lands; /-brushland; w-water; and blank-oak-hickory.

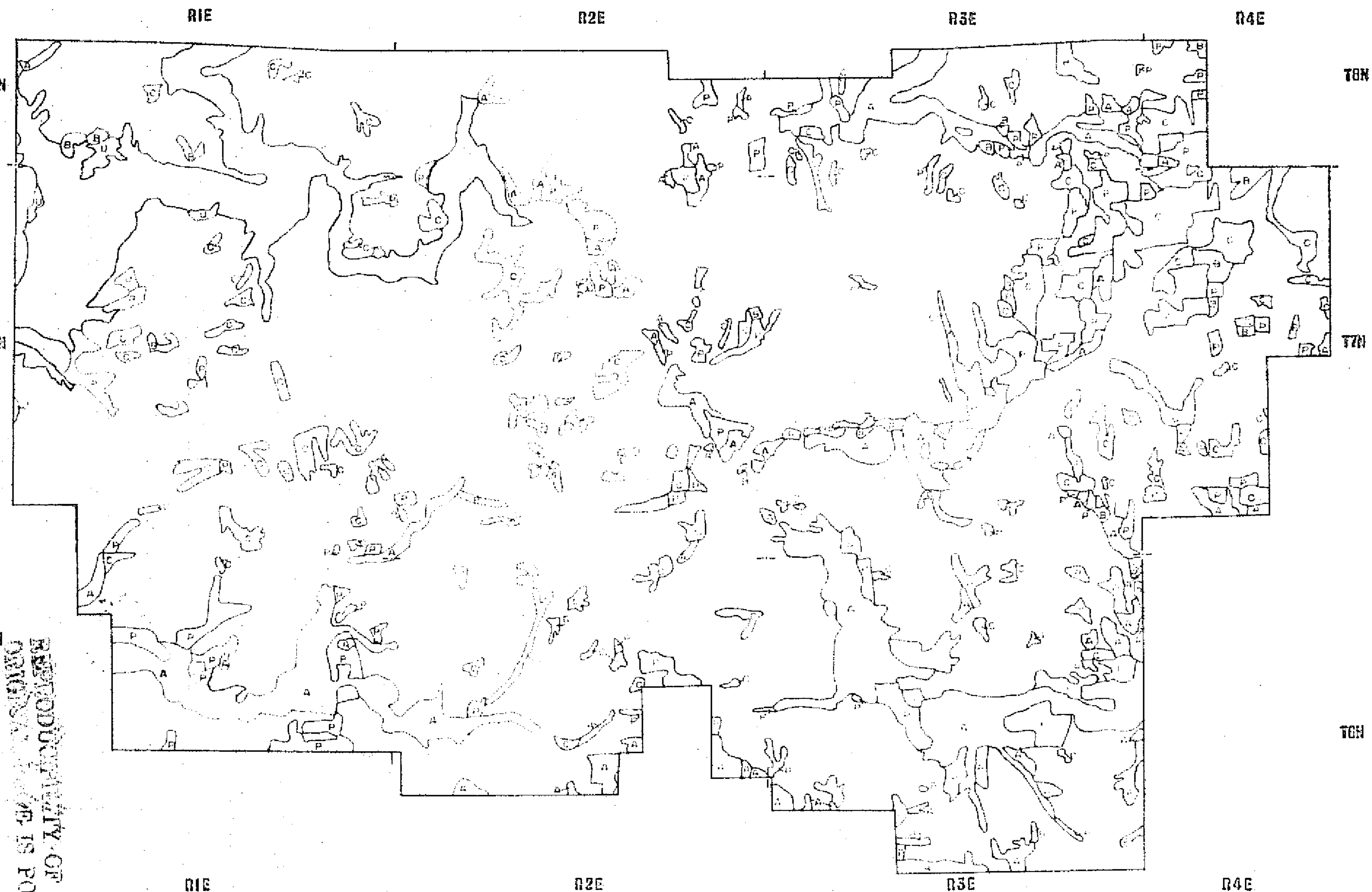
Table 1. Listing of the area by hectares, acres, and percent for each class identified on the printout in Figure 3.

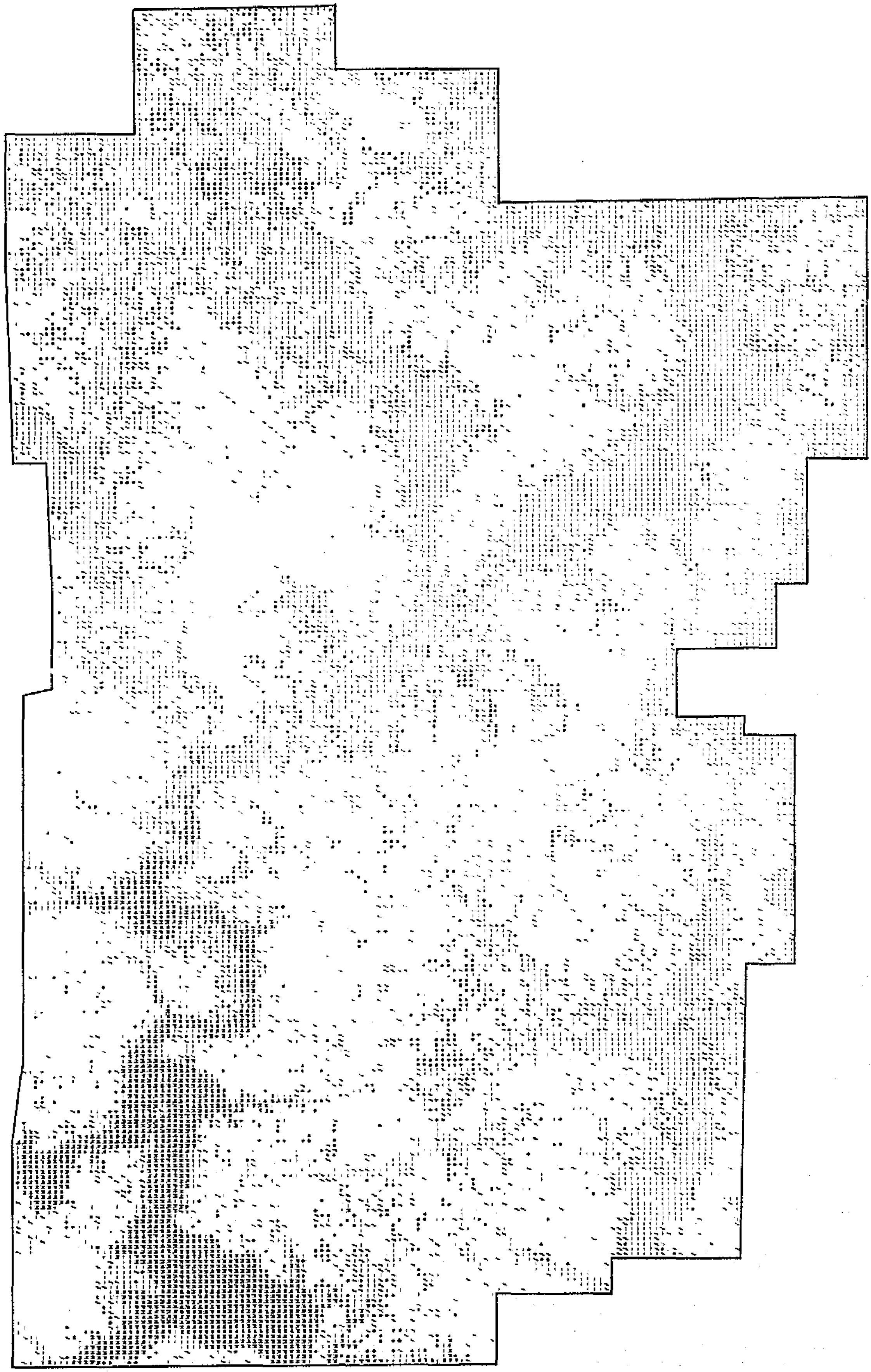
GROUP	POINTS	ACRES	HECTARES	PERCENT
HARDWOOD	66843	78294.4	31698.1	56.1
CONIFER	8761	10261.9	4154.6	7.4
BRUSH	13377	15668.7	6343.6	11.2
AG	23788	27863.3	11280.7	20.0
WATER	6278	7353.5	2977.1	5.3
TOTAL	119047	139441.8	56454.2	100.0

EACH DATA POINT REPRESENTS 1.17 ACRES
0.47 HECTARES

CLASSES NOT CONSIDERED	NO.PTS.
N	32741
TOTAL	32741

TOTAL POINTS IN CLASSIFICATION = 151788


R1E
R2E
R3E
R4E
T8N
T7N
T6N



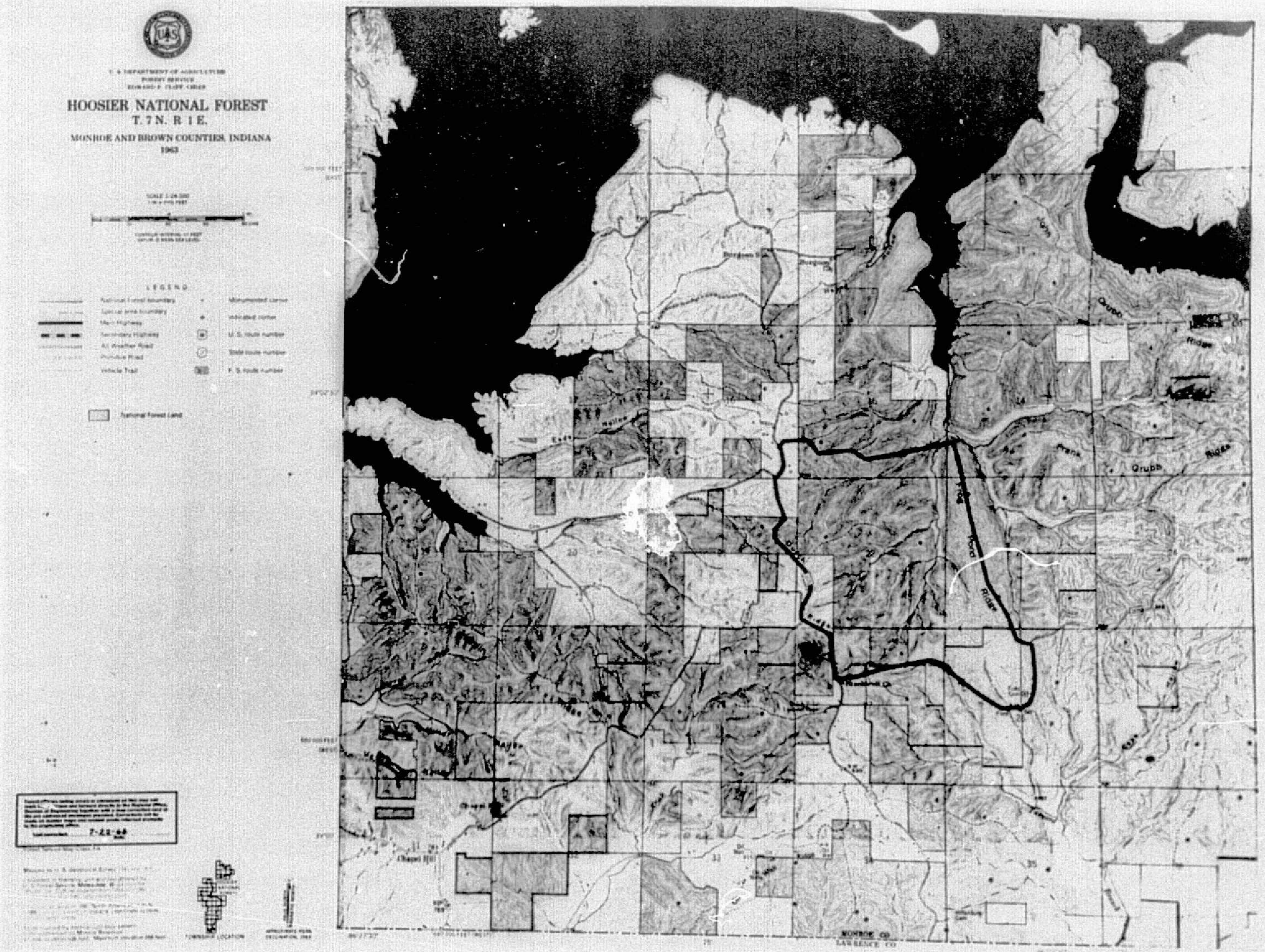


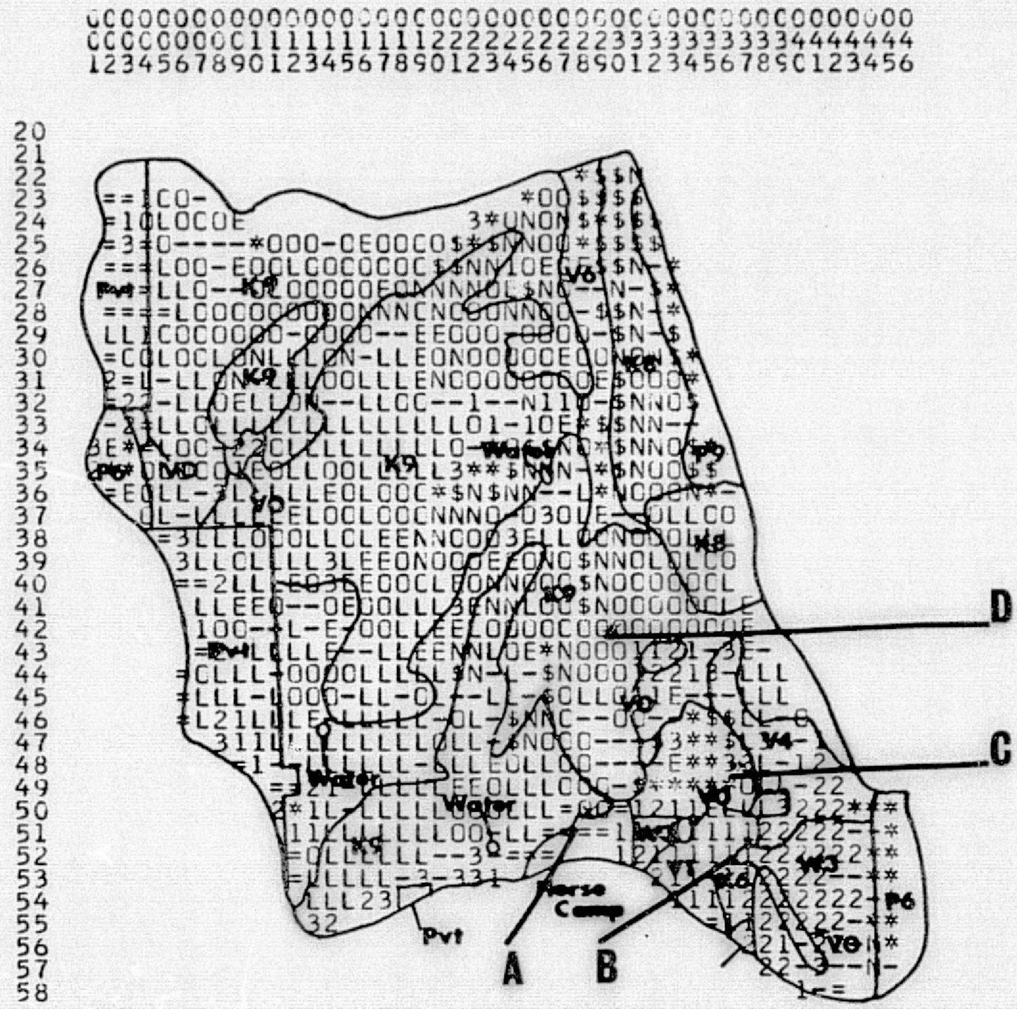
Figure 4. Forest ownership map (shading) for Township 7 North, Range 1 East of the Brownstown District of the Hoosier National Forest. The outlined area which encompasses most of Section 22 is Timber Stand Compartment 32.

Figure 5. LANDSAT classification (facing page) of timber stand compartment 32 (outlined in Figure 4) overlayed with a Forest Service type map. Header information and table indicate the classes identified. Table 2 gives the key to the Forest Service type map. The letters refer to Figure 6.

Table 2. The table indicates the type condition class and stocking of the material mapped in Compartment 32, Figure 5.

Type	Stocking
Oak-Hickory	
K-9 Sawtimber	70+%
K-8 Sawtimber	40-69%
K-6 Poletimber	70+%
Southern Pine	
P-9 Sawtimber	70+%
P-6 Poletimber	70+%
White Pine	
W-3 Seedling & Sapling	70+%
Cove Hardwoods	
V-6 Poletimber	70+%
V-4 Poletimber	10-39%
V-1 Seedling & Sapling	10-39%
V-0 Nonstocked	

SYMBOL	CLASS	SYMBOL	CLASS
1	BRUSH	L	LEV-DEC
C	DECID	L	LEV-DEC
E	SE-DEC	3	BRUSH
-	SP-DEC	C	DECID
	H2O-CLR	-	SP-DEC
	H2O-TURB	*	CONIFER
=	BS-ROAD	N	NW-DEC
=	PASTURE	$	BOTM-DEC
2	BRUSH		NULL



GROUP	POINTS	ACRES	HECTARES	PERCENT
BRUSH	144	165.6	67.1	14.0
DECID	261	300.2	121.5	25.3
SE-DECID	53	61.0	24.7	5.1
SP-DEC	118	135.7	54.9	11.4
NW-DECID	73	84.0	34.0	7.1
BOTM-DEC	55	63.3	25.6	5.3
LEV-DEC	235	270.3	109.4	22.8
CONIFER	49	56.4	22.8	4.7
PASTURE	44	50.6	20.5	4.3
WATER	0	0.0	0.0	0.0
TOTAL	1032	1187.0	480.6	100.0

EACH DATA POINT REPRESENTS 1.15 ACRES

0.47 HECTARES

CLASSES NOT CONSIDERED NO.PTS.

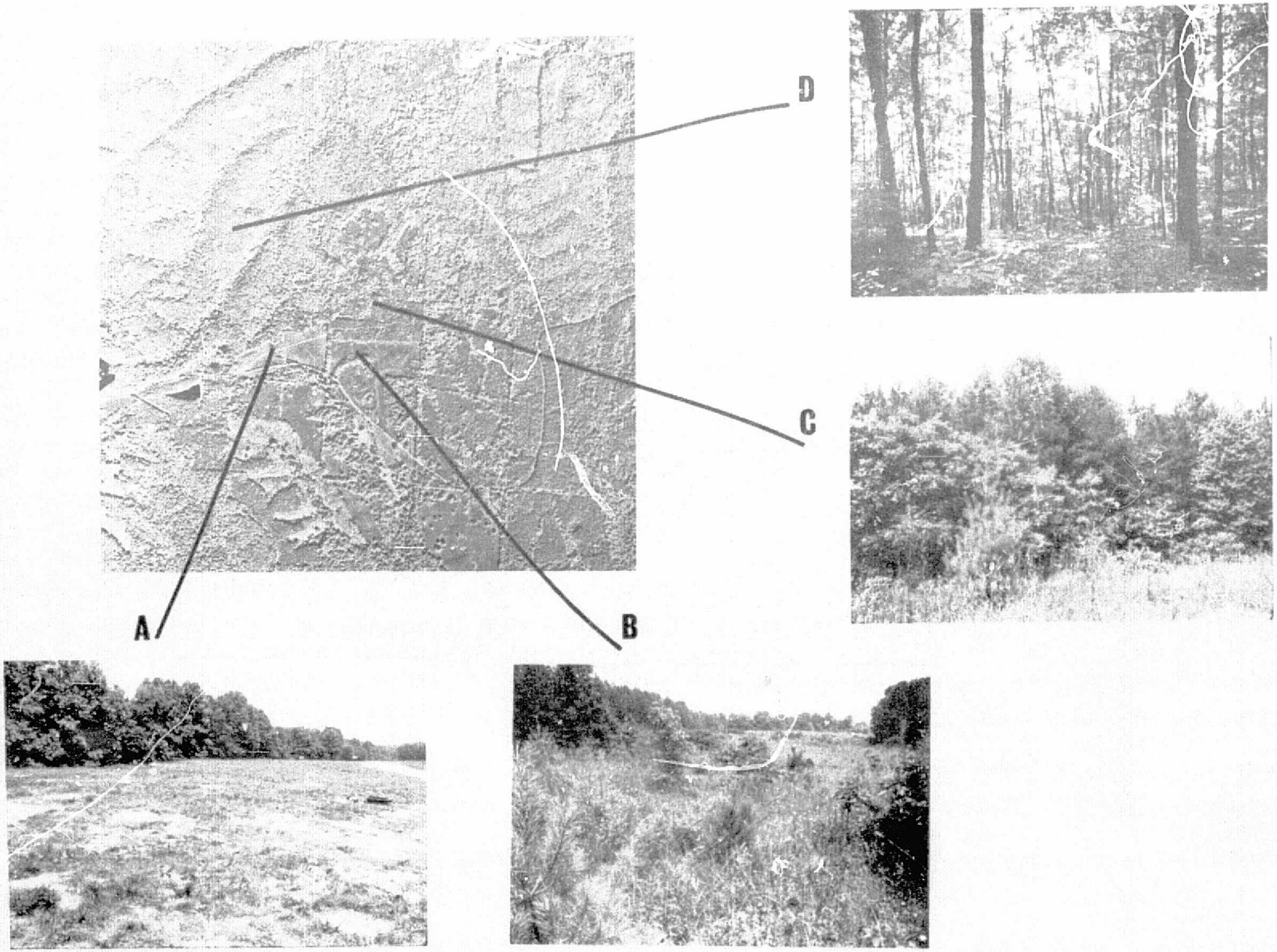


Figure 6. An example of Forest Service Resource Photography and representative ground scenes from within compartment 32. Detailed explanation in text.

photography is modified black-and-white infrared, collected at a contact scale of 1:20,000. The area shown on the aerial photography corresponds to the southeast portion of Compartment 32 on Figure 5. The inserts are ground photographs which give an indication of some of the cover types classified in Figure 5. The letters key the photographs to the approximate ground locations on the printout. (A) is a large open area identified on the Forest Service type map as a horse camp. This area was classified as a combination of bare soil, road (predominantly gravel) and pasture. (B) corresponds to the area of 1's and 2's on the printout. This area is classified as brushland, but it is actually a young plantation of pine. Areas such as this are difficult to separate from "pure" brushland or clearcut areas on the basis of spectral classes alone. However, the Timber Management Staff keeps records on planted or clearcut areas and can separate these areas from "pure" brushland based on this information.

Area (C) is not a typical pine plantation but serves to highlight a problem which must be faced in analyzing spectral data. Namely, the problem of accurately identifying a mixed pixel or a pixel in which the spectral data is composed of two distinct cover type responses - in this situation, pine and hardwood. On the classification, dashes (-), dollar signs ($), 3's and E's are possible candidate examples of a mixed pixel situation.

The (D) areas are the most common cover type on the forest - the oak-hickory association. These areas are represented on the printout as O's, N's and L's. Generally, these areas are densely stocked with co-dominant crowns which almost completely cover the understory. The prime difference in spectral response is associated with topographic position and illumination.

The tables at the bottom of the figure lists the area, in acres, hectares, and by percent, of each class in the compartment. Both graphic and tabular output can provide important information on the forest to the Timber Management Staff. Once adequately trained, the computer can provide unbiased timber stand information, within a relatively short time span, for each compartment of an entire management unit.

In addition to map-like output, acreage estimates are also available. If the timber manager treats this information in a multistaged sampling context, he would then have a good idea of how to allocate his ground sampling time. By so using the computer output, the manager would have more time available on the ground since the computer analysis will complement and quicken the amount of time otherwise spent in photointerpretation. We could, therefore, assume that the quality of the ground sample should increase, as would the amount of information collected. (Reference to letter from the Forest Supervisor dated June 17, 1975.)

Boundary Overlays

A common feature to all National Forests is that not all land within the forest boundary is under Federal control. For the Hoosier, less than 35% of the Purchase Unit Boundary is federally owned and controlled. An important part of the planning process revolves around information available based on ownership boundaries.

LARS has recently undertaken the task of hand digitizing township and ownership boundaries for the Brownstown District. This information will be

entered as a separate data channel so that information about cover type can be assessed for either class of ownership (federal or "other"). There are various applications of this capability, but allocation of fire suppression resources has been repeatedly highlighted by the Supervisor's staff.

The Forest Supervisor's staff could utilize this capability to allocate fire suppression costs between the Forest Service and State where common boundaries are shared. Also, the ownership overlay could be used to highlight potentially hazardous fire areas such as brushland and pasture. By so doing, fire crews could be strategically placed so as to more rapidly prevent the spread of wildfires.

Currently, LARS staff are trying to identify a recently collected LANDSAT-2 scene which includes the demonstration area. Once identified, the data will be acquired from the EROS Data Center, reformatted, geometrically corrected and overlaid onto the existing 7-date overlay. A classification will be attempted stressing identification of permanent pasture, brushland and agricultural land. These classes will be separated by ownership and the output map given to the Superviosr's staff for their use.

SUMMARY

Results

The opportunity to work with the Forest Supervisor's staff on the Wayne-Hoosier National Forest has highlighted some significant facts:

- Level I (U.S.G.S. Circular 671) and better classification of land uses are possible utilizing LANDSAT data and computer analysis techniques.
- More detailed classifications, such as timber stand mapping, is possible with LANDSAT data and good quality reference information (such as current aerial photography).
- The ability to manipulate ancillary information such as ownership boundaries is extremely important to the Forest Supervisor's staff.
- The procedure which allows the user to identify the objective to be pursued has been tested and was found to work very well in this project.

Conclusions

* Computer-prepared land use maps and tabular acreage results from LANDSAT data can be useful to the Forest Supervisor in preparing Forest Plans.
* The ability to rapidly acquire new, basic cover-type maps which include ownership patterns will prove useful in allocating fire suppression resources.
* Detailed timber stand maps, based on spectral/informational classes, will be beneficial from a cost standpoint (especially allocation of human resources) because of anticipated savings in photointerpretation cost and improved ground survey.

Attachment 4.1

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Wayne-Hoosier National Forest
Bedford, Indiana 47421

8200 2400 2300
June 17, 1975

Mr. Dick Mroczynski
Laboratory for Applications of Remote Sensing (LARS)
Flex Lab 1
1220 Potter Drive
West Lafayette, Indiana 47906

Dear Dick:

We would like to make you aware of some of the responses and impressions of our Staff following our Bedford meeting on May 29, 1975. During this meeting you made us aware of the capabilities of your analytical system for determination of general forest cover types in the vicinity of Monroe Reservoir.

General Comments

1. This type of information can be a very valuable tool for our land use planning program.

2. The accuracy limits of the results we reviewed appear to be more than satisfactory for our Level II planning requirements. With some modifications such data might also assist planning and inventory efforts at Level III.

3. There is potential for this kind of information as related to inventory, interpretation and evaluation for watershed and wildlife analysis.

4. If this information can be summarized, as you have suggested, by USFS ownership, watersheds, and timber compartments, it will be even more valuable for our planning program.

Discussion

The following discussion relates to the general comments made above:

1. For our current planning work (Level II-see attached descriptions), we feel that our data base is not very strong in terms of uniformity and detail. Although results of your work will not become available

2.

in time to develop our Forest Plan-Part I, it will be of significant benefit in helping us verify the results of the work we accomplish without it. We generally feel that it will modify and improve the original interpretations relative to forest cover types. We expect to adjust resource output targets based upon your work.

2. For Level II planning work, we currently use forest cover type delineation criteria which would exclude units smaller than 20 acres in size. It appears that your analytical procedure would produce delineations of units 10 acres and smaller. Your work would greatly improve our current maps. Our maps were done by hand using 1:15,460 scale black and white, air photographs. By combining these two sets of delineations, it is anticipated that the final product will represent a very significant improvement.

It might be possible to "fine tune" your data analyzing procedure and produce products which can be of significant benefit to us in Level III planning (Unit Planning). We feel that it may be possible to separate special species of deciduous trees to such detail that we can use the data to help outline 10-year harvest programs. If your data can be filtered, screened or otherwise "fine tuned," to help us determine age classes and stand densities, then there is little doubt that such information could be of significant application in making project level decisions for Level III planning.

3. "Wetland" inventories are considered a high priority need for helping guide our land acquisition to compliment the current wildlife program. There is additional need to identify wildlife openings. These openings are usually small (2 acres to .5 acres) and may not be discernible with your data.

In many places, inside the Proclamation Boundary, our hydrologic data is incomplete because we do not own much of the land. We feel that there are opportunities to use some of your information (as yet not reviewed) which could benefit us in helping to make gross water quality-quantity determinations. "Wetland" determination might also help in defining groundwater levels as well as assisting in the wildlife program.

Additional benefits to wildlife interpretation might be realized if oak stands of plus 40-year age can be delineated.

4. Planning for land use and financial management places very strong demands on us to summarize data which relates to our resource locations and capabilities to produce them. We do not understand how digitizing land ownership lines might complicate your program, but this would greatly benefit our management programs if your information could be summarized according to our ownership.

3.

There are other delineations, much simpler to make, which would also benefit our planning program: Forest Boundary, District Boundary, Planning Unit Boundaries, and Timber Compartment Boundaries. You are already aware of the Forest Boundary. There are two Districts on the Forest, which roughly divide it in halves, and 8 Planning Units. There are many Timber Compartments which are subdivisions of Planning Units; these have not been counted but are estimated to number about 160 (size usually exceeds 1,000 acres). All of these delineations can be made available upon request.

We learned a great deal from the recent "demonstration meeting" in Bedford. We feel that you clearly understand a few of the technical complications related to your analysis and look forward to receiving your next refinement. It is expected that through some mutual field checking and staff evaluation we can apply your results to our work in the near future.

We look upon this type of information as having high potential for meaningful application to forest planning and special program management.

Sincerely,

Donald S. Girton

DONALD S. GIRTON
Forest Supervisor

Enclosure
Cy Land Use Planning Process

W-H.N.F 6-10-75

LAND USE PLANNING PROCESS
Forest Service R-9

The U.S. Forest Service has developed a three-phase planning process for land use that is designed to be dynamic. It is responsive to current and changing legislation, budget levels, national objectives and public concerns. The three phases (or levels) of planning are:

Level I: Development of Area Guide
Level II: Development of Forest Plan - Part I
Level III: Development of Forest Plan - Part II (Unit Plans)

Each level is a prerequisite for subsequent level and is essential to its development. All planning emphasized interdisciplinary participation of resource specialists. The following outlines the general scope of each level:

Level I (Area Guide)

Planning documents, called "Area Guides" are developed for very large land areas which usually contain millions of acres. These large areas are called PLANNING AREAS and exhibit general physiographic uniformity. It is assumed that land use patterns, resource production and resource demands will be uniform in such areas.

Area guides examine gross trends in use and production of resources in the Planning Area. This document defines latitudes of management for individual programs and establishes long-range resource output levels for each Forest in the area. This sets the broad direction for each Forest in meeting area goals related to economics, environmental quality, and cultural development.

Level II (Forest Plan - Part I)

Planning at this level begins with direction established in the Area Guide and makes generalized decisions about HOW and WHERE to produce resources for each Forest. To help accomplish this, each Forest is divided into several PLANNING UNITS which exhibit uniformity of elements considered to be locally important to resource production or protection. Such units usually vary between 40,000 and 150,000 acres in size.

Significant resources are grossly identified within each Planning Unit according to location and quantity-quality characteristics. These resources include AIR, WATER, SOIL, WILDLIFE, RECREATION, SCENERY, TIMBER, MINERALS, UNDEVELOPED LAND, and SPECIAL (includes special historic, archaeologic, geologic, cultural or biotic areas). Decisions are made related to production targets and management objectives for each Planning Unit. This is accomplished in such a way that the Forest meets its full share of resource commitments shown in the Area Guide.

Specific Forest management direction for program development and Forest coordinating requirements are provided at this level. This direction is specific enough to formulate an interim project management guide while UNIT PLANS are being completed.

Level III (Forest Plan - Part II)

Planning at this level begins with direction in "Part I" and makes detailed analysis in each Planning Unit for suitability and capability of lands to produce the mandated resources. Detailed project-level studies and inventories are usually needed to support decisions made at this level.

Detailed project plans for a 10-year period are developed which show locations of timber sales, road construction, recreation developments, etc. Such plans include documentation of activity schedules, financial needs and manpower requirements.

SUMMARY

To date, this program has been aimed at the dissemination of remote sensing technology to use agencies within the state of Indiana. The thrust of our effort has been to acquaint these organizations with remote sensing through talks, demonstrations and actual problem solving projects that are directly associated with rhese agencies. The level of awareness of remote sensing technology and its usefulness have increased greatly in Indiana over the past years. As members of LARS meet with governmental organizations, the discussions are now more pointed toward how remote sensing may be applied to specific problems rather than merely trying to educate the interested persons in the technology itself. The projects included in this report are the sum of LARS efforts during the past six months to accomplish this goal using the funds available from the Office of University Affairs.

The results of and userinterest in these projects are very encouraging. For example, as described in our letter of November 20, 1975, the soils program is making tremendous progress. Personnel of the USDA/Soil Conservation Service of Indiana have been very receptive and are planning to incorporate the use of remotely sensed soils data into their county survey efforts. It appears that the power plant siting project may lead to a larger joint effort between Purdue and Indiana University concerning a Midwest energy facilities impact study. Remotely sensed data would be utilized as a significant input into this effort to produce land use inventories, soil maps and to measure the thermal properties of water bodies within the Ohio River Valley. USDA/Forest Service personnel have eagerly cooperated with LARS in our demonstration project in the Wayne-Hoosier National Forest. The products of this project will be used by the Forest Service with regards to timber management, fire control, wildlife habitat management general planning and land acquisition.